THE

ELECTRICAL REVIEW.

VOL. XXX. JUNE 3, 1892. No. 758

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Published every FRIDAY, Price 4d.

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GREAT CONFERENCE OF TELEGRAPH CLERKS.

THE present will be a busy—and, we venture to observe, a memorable—week in the annals of the Postal Telegraph Clerks' Association, the annual conference of which will be held to-morrow (Saturday) at Cannon Street Hotel. London district and country delegates, to the number of upwards of two hundred, will be present to represent their postal telegraph colleagues throughout the United Kingdom, and the whole day will, it is expected, be taken up in the debate of matters of paramount importance to this body of public servants, and, in not a few respects, of interest to the telegraph-using public.

The agenda is of great length, and covers much ground, of which probably most of our readers have heard something from time to time. As the classification system of pay, with its train of anomalies, is still rampant throughout the Telegraph Service, it is not unnatural that it should hold a large place in the business set for discussion. Matters affecting the question of pensions, annual leave, structural and hygienic arrangement of offices, with many other technical points, form the bulk of what may be called the purely official features on the agenda. There is also reference to the social questions of the still unsatisfactory and unsettled "Cardiff exile" incident, the right of free meetings, and free speech.

From the action pursued by the present Postmaster-General it seems reasonable to suppose that he does not approve of official interference, in these latter much-vexed affairs, and it is not unlikely that the effect will be to save him a few useful votes in the near future.

The question, much exaggerated, of "errors in telegrams," of which a little that was reasonable and much that was absurd was made by the press and numerous correspondents a little time since, has not escaped the attention of the conference, and it is with no little pleasure that we notice resolutions put forward by the telegraph staff themselves, having for their end the minimising and, as far as possible, prevention of, errors, by means which may be suggested by a serious and responsible body of experienced telegraphists. This course of action is clearly to the advantage of the public, and ought also to be appreciated by the Postmaster-General and his colleagues at St. Martin's-le-Grand. No one will deny that errors do unfortunately occur, and it is a good thing to see that telegraphists themselves feel anxious to have their house put into order.

As the London staff are playing the part of hosts to their country guests, arrangements have been made to render the occasion one not to be readily forgotten by those accepting the hospitality freely and fully extended by postal telegraph clerks in this huge metropolis. A series of entertainments and excursions have been carefully arranged by the reception

committee, and this day (Friday) the delegates will visit the Electrical Exhibition at the Crystal Palace, a journey singularly appropriate, and one which will fully interest appreciative country telegraph clerks.

This evening a reception will be held at Cannon Street Hotel, to be followed by a grand Bohemian concert in honour of provincial delegates. To-morrow, Saturday, as already mentioned, will find the Conference engaged in serious and important work. This meeting also takes places at Cannon Street Hotel.

Upon the conclusion of the Conference business, the delegates will be entertained at a monster banquet at the same hotel. This will be the greatest affair of its kind ever witnessed in the career of telegraphy, as upwards of 600 postal telegraph clerks, including many ladies, will assemble, under the auspices of the London branch of the Postal Telegraph Clerks' Association.

Sir John Puleston, M.P., will be chairman at this huge feast, a position to which his valuable services and sympathies fully entitle him. Sir Albert Rollitt, M.P., LL.D.; Mr. Ambrose, Q.C., M.P.; Mr. Dalziell, M.P.; Mr. Kimber, M.P.; Mr. Murdoch, M.P.; Mr. G. Howell, M.P.; Mr. M. H. Beaufoy, M.P.; and Mr. Willox, M.P., will also be present. Letters containing cordial sentiments have been received from Earl Compton, M.P.; Mr. Lockwood, Q.C., M.P.; and Sir James Fergusson, the P.M.G., expressing their inability to be present. In the case of Mr. Ambrose, it may be remembered that he opposed Lord Compton's motion in the House of Commons, when the noble lord moved for an enquiry into Post Office affairs in general, and telegraph matters in particular.

The outcome of all this indicates that telegraph clerks have claims based on grounds more substantial and serious than can be appreciated by those who only occasionally hear that grievances exist in this direction or in that, and the fact that their case is taken up by public men—and that, too, quite apart from party politics—is a significant and trenchant commentary.

In these matters we have always counselled methods of propriety and discretion; a good case stated with fairness and reason can always be made to stand the strongest test, when by exaggeration and extremes the whole fabric is shaken. From what we know of telegraph clerks, such advice is hardly in danger of being wanted by them, but it is well to bear it in mind. We, with many others, await with some interest the result of to-morrow's Conference, in so far as it affects matters telegraphic.

THE MADRAS ELECTRIC TRAMWAYS COMPANY, LIMITED.

Indian Engineering for April 30th has a very interesting leader on the prospectus of this proposed company. We are accustomed to electrical limited liabilities in this country of progress, and appreciate them thoroughly—they form such a convenient outlet for our superfluous cash, and mostly "give a run for our money." But we are surprised that these blessings of civilisation should be thus lavishly extended so far east. We have not seen the text of the prospectus; but judging from a letter anent this, signed by "Black Town," in the same issue of our contemporary, it must be very entertaining reading. The chairman of this promising concern is Mr. Digby, C.I.E., and the managing director, Mr. Chalk. The motto of the company appears to be "India for the Indians," with the management in England. So entertained is "Black Town" with the scheme, that he suggests the promoters should "*Chalk* out the lines" on which the company propose to act. Can this be a joke?

Anxious as we are to see electric traction pushed both here and abroad, we cannot but think that the memorandum of association, as explained in *Indian Engineering*, is too comprehensive to work. The capital is to be £100,000 sterling, in £1 shares, and it is estimated that half of it will be subscribed in India. The line to be worked covers 18 miles of road, including sidings, and is divided into six sections. The estimated cost per mile is £5,000, and the profits are reasonably fixed at 15 per cent. as a maximum. The system by which these splendid results are to be obtained is not stated, but a number of alternative schemes are given, which probably the Board will try in detail until they find the proper one, or the company liquidates. We have seen some curious prospectuses in our time; but apparently this stands alone. The last Madras tramway was a dismal failure, and the chances of the new one now proposed seem to be about "the size of a piece of *chalk*."

ALTERNATE CURRENTS.

ONE of our contemporaries lately made merry over the difficulties of the unfortunate alternating current engineer. The writer coins the catchy term "a wattless-ampère" to express currents which are required by the condenser action of the mains, and are in quadrature with the working current and the impressed E.M.F. The term is taking, but is it quite accurate? Surely, while we have resistance in the cables, these currents cannot be truly described as "wattless," for, without zero resistance, no current can be termed "wattless," and in this case the currents required by the condenser action of the main have to pass along it. What the writer meant was to express the fact that this component of the actual current is more or less in quadrature with the impressed volts, and consequently absorbs little power; from that point of view the term is to some extent defensible, although taken *per se* it is certainly not.

With regard to the wattmeter difficulty in measuring these currents, it should not be an impossible task to design a wattmeter for station use which will not only measure the useful watts supplied to the transformers and the magnetising current watts, but also the condenser watts for the mains. Our contemporary seems also to consider that the question of alternate current ammeters is one of difficulty, inasmuch as the calibration depends on the frequency in many cases. Surely this is not a matter of any importance: an ammeter can be calibrated for any desired frequency, and we know of at least one type which is as accurate as can possibly be required at or about its designed frequency. Now, the error in reading for variation of frequency would be of the order of second differences, and as the frequency at a central station varies by a fairly small amount, the error occasioned by this

cause in any decently designed ammeter would be absolutely negligible.

Again, the writer of the article seems to anticipate difficulty in the use of pilot transformers for the cardews, as he considers the ratio of transformation is liable to variation; surely if the transformer is working on a Cardew, which has little inductance and almost absolutely no capacity, the fear of a variable transformation ratio is quite unfounded; the only thing to take care of is that the pilot transformer should be of proper design to avoid any appreciable magnetic leakage.

Although there are the above, and some other minor points, to which we must take exception, we can heartily agree in the main contentions, that difficulties occur in alternating work, and that the operation of good workshop experience in this branch of the profession will serve to dispel much of the somewhat misty notions prevailing on the subject, with which even our contemporary seems to be a trifle afflicted.

THE TELEPHONE QUESTION.

THE proposals of the Government in regard to telephones will need very careful examination by the public, and we believe considerable alteration will be required before they can meet with approval. It is unfortunate that the public is uninformed as to the true nature of telephone exchange work. They depend almost entirely upon the statements of interested parties, and they are liable in consequence to be very much misled. The question is one of extreme difficulty, and proposals put forward with the best possible intentions may produce exactly the results they were intended to avoid. In another article we have drawn attention to some of the drawbacks—by no means all—of the Government plans. The difficulty is to propound any scheme which shall meet all the considerations which are involved, but one condition is essential, the scheme must be sound in principle. The present scheme is entirely unsound. One point of considerable public importance is the value at once given to existing all-England licenses by what we believe to be the unnecessary declaration that no more will be granted.

Two such licenses exist; one to the National Company, the other to the New Company. On the first royalties have been paid for work done. On the other nothing has been paid because no work has been done. The public has been induced to pray to the Government to be delivered from a full grown lion, and the principal deliverance the Government can think of is the supplementing of the full grown lion by a new born one as a check. There is apparently an assumption that the tendencies of lions are to prey on one another, an assumption which we believe to be mistaken.

The Government proposals place an asset of considerable value at the disposition of the new company, for which in one direction there might be a ready market. For this asset nothing has been paid, and there is, as far as we can see, nothing to prevent an agreement between the respective licensees to gobble up the public between them. It may be at present as far as possible from the minds of both, but the motives of each are the making of money, and the easiest way of doing it will at some time or other become apparent.

The whole question needs very broad handling. On the publication of the Postmaster-General's statement we remarked that it seemed a case of meddling and muddling. The Treasury minute confirms that impression. The Government is placing itself in a position which no Government, least of all a British Government, should be in, and we doubt very much whether there is any way of settling the question satisfactorily besides that of absolute free trade or of Government purchase.

A New Application of the Electric Light to Surgery.

THE illumination of the internal cavities of the body cannot be efficiently performed by any light but that supplied by electricity. This statement will scarcely be questioned by even the most rabid gas-shareholder. Coal gas can do nothing in surgery or medicine—electricity has done much and will do more towards making surgery an exact science. One of the latest applications of the electric light to surgery is a small apparatus for examining the cavities of the face. It consists of a small five candle-power incandescent lamp, surrounded with a second glass covering, which protects the tissues near which it may be placed from undue heat, and which also minimises risk from accident to the lamp. Mounted in a vulcanite tray, it has free communication with the external air by means of tubes which go through the vulcanite and also carry the wires: thus it is kept cool for all practical purposes. The vulcanite tray prevents as much as possible the light from escaping from the mouth through the teeth and lips. The effect, in cases of suspected disease is so decisive that it seems impossible to make a mistake in diagnosis, for if any obstruction exists, the darkness on that side of the face where it is located is so strong a contrast to the light on the other side, that the patient observes a red glow in the one eye and not in the other. If there is no obstruction the glow is equally visible in both eyes. The lamp is used in a perfectly dark room. The teeth are closed over the lamp on to the vulcanite tray, and the lips tightly drawn over the front flange of the tray, thus leaving outside the mouth only the metal tubes to supply the air to the "jacket" of the lamp and carry the electric wires. The current to supply the lamp is taken from that supplying the house, but is reduced by a resistance coil to the necessary volts.

Recent Work with Alternating Currents.

ONE of the best and most succinct accounts of recent work in the field of alternating currents is given by Prof. Eric Gérard in *L'Electricien*, of May 21st. In the form of an address at Liege, he gives a truly admirable *resumé* of the work of Hertz, Tesla, and Elihu Thomson. It is impossible to summarise a summary, and so we merely recommend the perusal of this article to those wishing to get a brief account of what has recently been accomplished in the domain indicated above.

Edison Feeder Case.

THE celebrated Edison "feeder and main" case has at last been settled in favour of the litigious patentee. We can scarcely congratulate the electrical profession on the verdict, which we are afraid will have a serious effect upon low tension distribution in America at any rate. We do not pretend to judge the merits of the case, but only view the matter in its broadest aspect. However, the abstract from the New York *Electrical Engineer* for May 18th, which we reprint in our columns, is not only characteristic of patent law, but is also instructive owing to the course pursued by the Edison Electric Light Company. In order to clearly bring before the court the principles involved a very complete set of hydraulic analogues was carefully prepared and erected in court, the power being supplied

to the systems by an electric pump. This technical instruction of the "Bench and Bar" is decidedly cute, and the idea is worthy of consideration for the next patent suit on this side of the Atlantic. We do not like to mention names, but several good openings for such displays suggest themselves to us, and we can imagine some of our prominent electricians acting as showmen in the law courts.

Shunting Carriages by Electricity.

INSPECTOR BRETTMAN, of the Prussian State Railways, proposes to use electric motors instead of locomotives for shunting. He suggests the use of electric windlasses between the tracks so that several may be used simultaneously to move a heavy train, while one would be sufficiently powerful for a few carriages. In certain cases he advises the use of motor cars with gears engaging a rack alongside of the metals. The latter proposal is only made feasible by the fact that the distance travelled by a shunting locomotive is very small, and therefore the cost of transmission is of little importance compared with facility for rapid movement on zigzag tracks. Electric windlasses are not new and certainly will advantageously replace steam ones as soon as electric power is supplied for lighting stations and yards.

Technical Education.

IN the *Technological Quarterly* will be found an interesting article by Mr. F. Walker on "The place of Scientific and Technical Schools in American Education." He points out the important fact, that the supply and demand do not always occupy the relative positions that economists usually think, but that (as in the case of technical schools) the order is reversed. The American schools of technology, he says, created the demand for technically trained men, by showing to the world the value of a supply of such men in organising and directing industry. The educational value of scientific training is insisted on as being fully equal, if not superior, to that of a classical curriculum, and a pretty point is made by contrasting the sincerity of purpose and honesty of thought engendered by working in touch with nature, with the somewhat opposite tendencies which beset the pursuits of metaphysics, rhetoric, &c. With his attacks on the ordinary examination system we are fully agreed, and it is one thing in favour of the study of natural sciences and their applications that examination results of the "cram" order are much less easy to get, and that actual practical work generally carries more weight than mere cram knowledge.

Note on the E.M.F. of Reversible Cells.

THE maximum tension with which hydrogen is set free from acids by dissolving metals in them is a measure of the maximum work obtainable in this way, and since the electromotive force of so-called reversible cells is a measure for the same quantity, it follows that this maximum tension is intimately related to the E.M.F. of such cells. Starting with this hypothesis, G. Tamman and W. Nernst have recently worked out the relation in mathematical terms (*vide Zeit. Physikalische Chemie*, ix., pp. 1—11) as follows:—If p be the maximum tension, and P the atmospheric pressure, the work which could be obtained from 2 grammes of hydrogen by liberation and transference from pressure p to pressure P would be

$$A = p\,v + R\,T \log. \frac{p}{P},$$

or, if the volume is taken in litres and the pressure in atmospheres,

$$A = 0{\cdot}0819\,T \left(1 + \log. \frac{p}{P}\right).$$

From this it follows that the work which could be obtained from a Daniell cell by the dissolution of a gramme-molecule of zinc and the precipitation of a gramme-molecule of copper is

$$A_1 - A_2 = 0{\cdot}0819\,T \log. \frac{p_1}{p_2}.$$

This work is equal to the electromotive force. On introducing the ordinary units of measurement, the expression becomes

$$A_1 - A_2 = 0{\cdot}430\,T \times 10^{-4} \log. \frac{p_1}{p_2} \text{ volt},$$

which contains the quantities p_1 and p_2, both of which are measurable directly. Messrs. Tamman and Nernst have endeavoured to test this relation by measuring the pressures under which hydrogen ceased to be evolved from solutions of metals in acids, but their experiments have up to the present been only partially successful, and do not afford definite confirmation of the theoretical deductions.

Long Distance Telephony.

MR. F. W. JONES, writing to the *Electrical Engineer* (New York), on this subject, and refering to the "K R" rule of the good speaking limit, makes the statement, "How is it that conversation can be satisfactorily carried on over a wire from Newark to Boston, *viâ* Pittsburgh, Buffalo and Albany, upwards of a thousand miles in length, having a K R of over 157,000 for the entire loop, when the rules laid down by Preece and H. R. Kempe state that the K R of a loop divided by 4 should not exceed 10,000 to insure good speaking?" It seems now to be generally admitted that the K R rule is actually limited in its application, and probably a more correct enunciation of the good speaking law would be: For good speaking, K R — k must not exceed 10,000— k being a quantity which in some cases (where the circuit consists of underground work, for example) may be equal to 0, but which in other cases may have a very high value. That this value may be so high as to make K R — k as low as 10,000, when K R exceeds 157,000, we hesitate to accept, and we should like to know the exact capacity per mile and resistance per mile of the line in question.

Half Baked Electricians.

THIS significant application which was given some time ago by Professor Marks in America to those so-called electricians who imagine that almost anything will do for electric light fittings, has been again brought to notice in connection with a fire which took place recently in a Philadelphia theatre. It appears that although it was proved that the fire could not have been caused by the electric light, the arrangements for the latter were such as to cause grave suspicions that the accident was due to gross carelessness in the wiring. If the trade had its way, uncontrolled by experts, we believe that the amount of bad and dangerous work which would be put up would be considerable. We know of at least one instance in which a well known firm informed one of their clients that "the electric light would never be made as cheap as gas as long as the electric light fitting firms had to work to the specifications now drawn up by the electrical engineers;" affirming, in fact, that the high quality insulation, &c., insisted upon was wholly unnecessary.

Magnet Iron.

WRITING to *Electricity* (American), Mr. W. S. Key suggests that with reference to the large amount of iron which is now used in the electrical industry for magnet purposes of all kinds "what is needed is that a few enterprising men with capital, should organise a company, secure the services of a first-class chemist who is well-posted in metallurgy, also a practical iron manufacturer —one who understands thoroughly the various mixtures, and an experienced roller. These factors together, would have no difficulty in securing results eminently satisfactory in every way, and considering the difficulties so long laboured under by electrical manufacturers, I don't doubt that in a short time a very profitable market could be secured for their entire output." The suggestion we think is worthy of consideration.

EXCAVATING TUNNELS AND ADITS BY ELECTRICAL MACHINERY.

[FROM OUR OWN CORRESPONDENT.]

SOME months ago I gave you an account of the so-called electric miner, a device for excavating adits. Since then thoroughly practical experiments have been made with this apparatus at different places to show its industrial value. I can now give you the following particulars on the results of these trials.

The general result culminates in the fact that for the real boring work, properly so-called, a strikingly smaller power is required. This favourable result is due chiefly to the circumstance that the breaking up of the soil is effected by the ploughs in a very advantageous manner. Only a small portion of the material requires to be crushed, whilst the larger portion only needs to be broken up into particles of the size of a nut. The quantity of the crushed material does not exceed one-fourth of the total mass, and as a relatively small force is needed for loosening the rest, the small expenditure of work becomes intelligible.

The experiments were undertaken with a boring machine intended for making circular channels of two metres in diameter for waterworks. Experiments have been made with this machine in various classes of earth, and the following results have been established. The speed of boring in all soils was so great that the introduction and erection of the provisional structure cannot keep pace with the advance of the machine, although the material for the structure was specially constructed for a very light arrangement and convenient manipulation. The boring machine had to be frequently stopped in order to complete the structure from metre to metre.

The preparation of the foundations and the screwing on of the rails could always be effected in time by two labourers.

The small diameter of the adit did not permit the removal of the earth to be effected by a flying line, for want of room. The dogs had to be brought close up to the machine and were filled there by means of a sheet metal spout which conveyed the earth, &c., thrown into it to the dog. Besides the track serving for the advance of the machine, of 1,000 mm. gauge, two other rails were laid down which formed with the external rails two lines of 400 mm. gauge. On the two lines thus formed side by side the dogs were pushed by hand. These were brought up on the left-hand line and were run away when filled on the right-hand line. To facilitate the transfer of the dogs from the left to the right line a drag turntable was constructed on which the empty dogs were brought up, with which they were transferred to the right track. The arrangement was such that the dogs could be filled while standing on the turntable. This manipulation could be effected so rapidly that the machine did not need to be stopped whilst changing.

The construction of the supporting rings was found perfectly successful. The two upper portions could be easily fixed upon the foundation piece (which had been previously laid down) and could be firmly connected both with each other and with the ground piece. These rings pressed very firmly against the excavated adit and rendered it so firm that no falling in of the material occurred even when boring in sand.

The work of the machine when running without a load could be determined only approximately for want of the opportunity for accurate measurements and by reason of the varying demands made upon the motive power. The measurements were effected by inserting such a resistance, whilst the consumption of current was measured simultaneously that the same velocities of rotation were reached as when boring in the different kinds of soils.

A knowledge of the work of the machine was of interest, as it was desirable to find the pure boring-work in different soils, including the automatic removal of the material excavated.

The following values were obtained: First experiment in stratified, very solid earth, interspersed with lime-stone. The boring was carried only to the length of 3½ metres, as the quality of the earth was variable. The mean working time per metre run of adit, duly bored and lined, was 57 minutes, including the pauses necessary for lining. The time taken up with boring, after deducting the time consumed in these pauses, was in the mean 33 minutes. Excavating and removing 1 cubic metre of material required 14 minutes.

The current consumed when running without load was 3,000 watts. For boring and removing it was, as a mean, 5,300 watts. The total consumption of current fluctuated between 7,500 and 9,000 watts.

Including the degree of efficacy of the electromotor, the production of 1 cubic metre of disintegrated material required 1½ H.P. hour.

Second experiment in moist adhesive clay interspersed with thin layers of a harder material. In this soil there was executed an adit, 45 metres in length, in which the direction was modified both horizontally and vertically. Here it appeared that when the rails are rendered slippery by moist clay, the adhesion of an apparatus weighing 3,000 kilos, in spite of coupled axles, suffices for pressing the apparatus against the front wall of the adit only on gentle gradients. On steeper gradients especial arrangements must be adopted for cleansing the line.

The mean working time per metre run of adit, including pauses, was in such clay, 36 minutes, without cleansing the clotted ploughs and shovels, the minimum was 30 and the maximum 42 minutes. If the pauses are deducted the actual time of work was, as a mean, 32 minutes, the respective extremes being 25 and 38 minutes. The production and removal of 1 cubic metre of material required, as a mean, 9½ minutes.

The work, when running unburdened, required approximately 3,700 watts, and for the boring alone the energy consumed was 6,500 watts. The fluctuations of the total consumption of current were from 8,200 to 13,000 watts. The work performed per cubic metre of material was 1·3 H.P. hours.

Third experiment in moist, loose sand:—

In an adit 10 metres in length, the progress of the work was approximately uniform, and the consumption of current was subject only to very slight fluctuations.

The introduction and erection of the superstructure required much more time than in other kinds of soils, because the entire upper half of the arch had to be lined with metal sheathing. Great caution was necessary.

The mean working time per sheathed metre run was 47 minutes, the mere boring requiring only 13 minutes. The excavation and removal of 1 cubic metre required rather more than 4 minutes.

The unburdened work required 3,000 watts, the total work 6,900 watts with fluctuations of about 10 per cent. For 1 cubic metre of sand dug out and forwarded there was needed only ⅓rd H.P. hour.

The data are presented in the following table:

	Shingle	Clay.	Sand.
Mean progress of work, minutes per metre	57	36	47
Advance of machine	33	32	13
Production of material, minutes per cubic metre	14·0	9·5	4·2
Unburdened work at axle, in H.P.	3·7	4·5	3·7
Total consumption of current minimum watts	7,500	8,200	6,600
" " " maximum "	9,000	130,000	7,200
Boring and removing work, H.P. hours per cubic metre	1·5	1·3	0·34

With larger machines of more than two metres diameter, the mean consumption of power will be less favourable, but the expenditure of time more favourable.

Larger adits can probably be bored at a rate of more than two metres per hour.

No geodetic measurements were undertaken in the experiments described. In practical workings such measurements must be carried out and corresponding corrections of the direction of the boring, for which a certain loss of time must be allowed.

Nevertheless, if the work is properly organised, a progress of one to two metres per hour can be effected by the method described in larger adits.

C

NOTE ON DYNAMO AND MOTOR CALCULATIONS.

BY ALBION T. SNELL.

THE fundamental equation of dynamo design connecting the total volts with the armature constants is well known to be

$$E = C\,n\,N\,A\,K \qquad (1)$$

where E = the average E.M.F.;
C = number of turns on periphery of armature;
N = magnetic flux per square inch;
A = area in square inches;
n = rev. per minute;
and K = a constant.

This equation simply states that the E.M.F. varies as the product of four variables, which, theoretically, may have widely different values, as long as their product is kept the same for given values of E.

If we alter the equation to the form

$$\frac{E}{A\,C\,K} = n\,N \qquad (2)$$

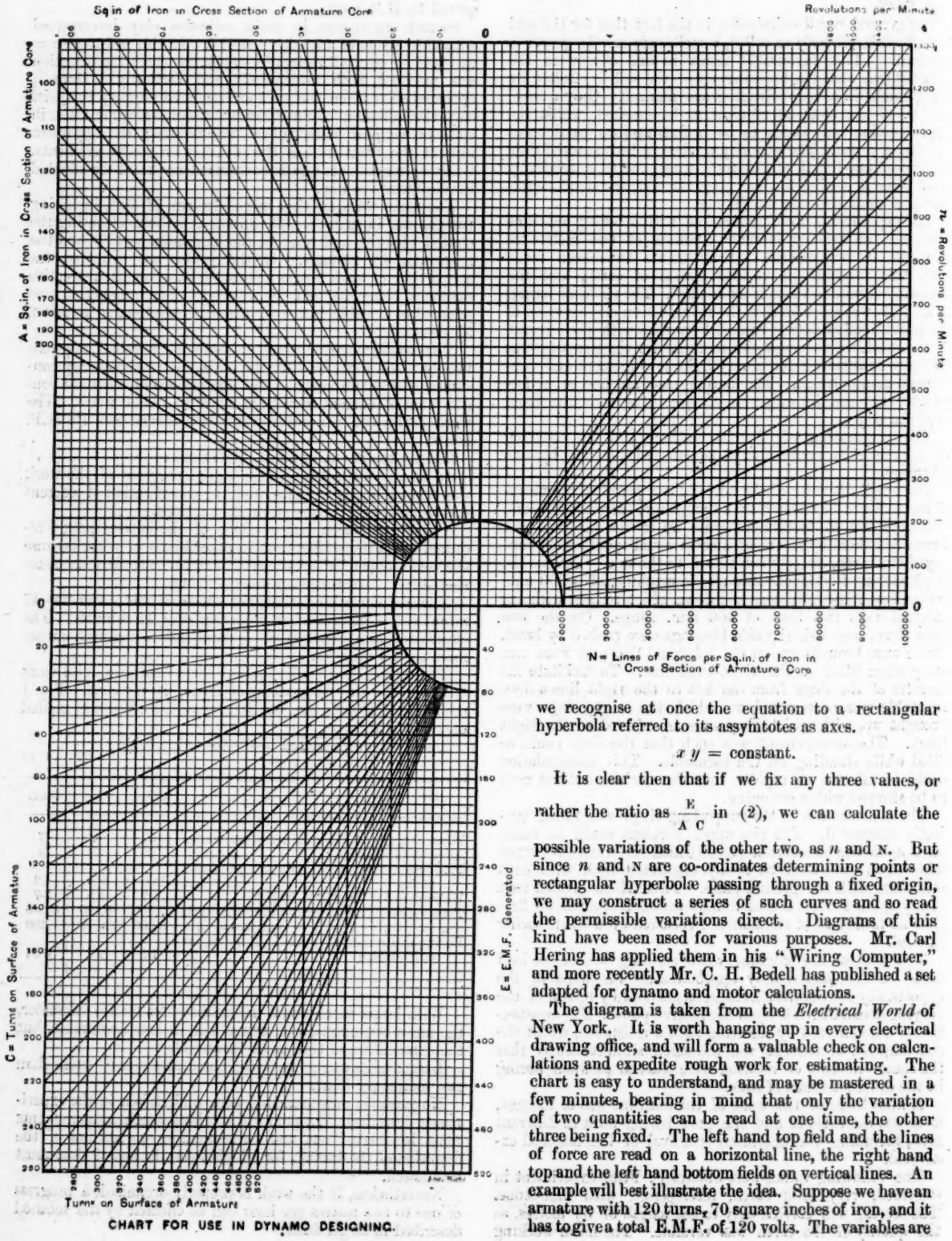

Sq in of Iron in Cross Section of Armature Core
Revolutions per Minute
A = Sq.in. of Iron in Cross Section of Armature Core
n = Revolutions per Minute
N = Lines of Force per Sq.in. of Iron in Cross Section of Armature Core
C = Turns on Surface of Armature
E = E.M.F. Generated
Turns on Surface of Armature

CHART FOR USE IN DYNAMO DESIGNING.

we recognise at once the equation to a rectangular hyperbola referred to its assymtotes as axes.

$$x\,y = \text{constant}.$$

It is clear then that if we fix any three values, or rather the ratio as $\frac{E}{A\,C}$ in (2), we can calculate the possible variations of the other two, as n and N. But since n and N are co-ordinates determining points or rectangular hyperbolæ passing through a fixed origin, we may construct a series of such curves and so read the permissible variations direct. Diagrams of this kind have been used for various purposes. Mr. Carl Hering has applied them in his "Wiring Computer," and more recently Mr. C. H. Bedell has published a set adapted for dynamo and motor calculations.

The diagram is taken from the *Electrical World* of New York. It is worth hanging up in every electrical drawing office, and will form a valuable check on calculations and expedite rough work for estimating. The chart is easy to understand, and may be mastered in a few minutes, bearing in mind that only the variation of two quantities can be read at one time, the other three being fixed. The left hand top field and the lines of force are read on a horizontal line, the right hand top and the left hand bottom fields on vertical lines. An example will best illustrate the idea. Suppose we have an armature with 120 turns, 70 square inches of iron, and it has to give a total E.M.F. of 120 volts. The variables are

then the speed and the magnetic density. The chart will show, on inspection, the allowable variation of these quantities, so as to conform with the imposed condition. Find in lower field where E cuts C, and trace up vertical line to meet A in left hand top field. Then follow horizontal line to right hand top field. This line cuts the possible values of n, and vertical projections give the corresponding values of N. The lowest speed within limits of the diagram is about 860 revolutions per minute, and this needs 100,000 lines per square inch. If the speed be taken at 1,000, then N must be reduced to 86,000, and so on.

The scale of the diagram covers all the usual sizes of machines, but calculations can be made far beyond the limits shown, since any two factors can be multiplied or divided by the same quantity, excepting N, for this latter is fixed by the saturation limits.

Primarily the scheme is for two-pole machines, but it may be used for multipolar windings, care being taken to distinguish between parallel and series connections. For example, if the armature be wound for a four-pole machine and be coupled in four parallels, then the curve will give the E.M.F. between two poles, which will in this case be the total E.M.F. But if the connections be in series (two brushes at 90°), then the chart value of E and N must be doubled, and so on; this is best seen from the equations for multipolar machines,

$$E = \frac{C\,n\,N\,A\,K}{\rho} \qquad (3)$$

where ρ = number of pairs of like poles connected in parallel, and

$$E = \rho\,C\,n\,N\,A\,K \qquad (4)$$

when poles are in series.

In (3) the armature current will be ρ times as great as that in (4).

It is hoped that this elementary description may be of use to students, and attention is drawn to the fact that the form of the armature does not enter into the equation; neither does the quantity of wire, nor the volts per foot affect the result.

SOME OBSERVATIONS ON ELECTRICAL VOLATILITY.

SEVERAL years ago Mr. William L. Dudley began to investigate methods for obtaining metals in their films, and a number of plans were tried, amongst them being: (*a*) electro-deposition and subsequent removal of the "base" on which the metal is deposited: (*b*) volatilisation by the electric arc between terminals of the metal enclosed in a glass tube filled with an inert atmosphere, and (*c*) volatilisation by the condensed electric spark under similar conditions. Each method had its value in particular cases; but no one method seemed to be capable of universal application, although the last mentioned was generally applicable.

Electro-deposition appears to be of limited application; gold films may, however, be readily produced, owing to the ease with which this metal is deposited. A difficulty is encountered in this method when endeavouring to obtain films of minimum thickness; this is largely obviated by a suggestion due to Kundt (*vide* "*Ueber die Brechungs exponentem der Metalle*," *Ann. der Phys. Wied*, xxiv., p. 469), by which a wedge-shaped film is obtained by placing the cathode horizontal in the bath, and the anode very near and perpendicular to the surface of the cathode. Thus the film tapers out to a thin edge.

The electric arc between terminals of the metal to be volatilised proves successful in a few cases. The terminals are inserted into a glass tube filled with an inert gas, and brought in contact for an instant. The metal is, under these conditions, suddenly vaporised and thrown upon the glass; but is often granular or powdery, of a black or brown colour, a character which is altogether unsatisfactory, owing to the discontinuity of the film.

The condensed spark between two points of the metal enclosed in a glass tube, or filled with inert gas highly attenuated, serves well in many cases, according to Mr. Dudley. For descriptions of this method in detail, our readers are referred to papers by Wright (*American Journal of Science* [3], xiii., 49; xiv., 169); Hartley (*Proc. Roy. Soc.*, xlvi., 88), and Crookes (*Chemical News*, lxiii., 287). Hartley, however, volatilised the metals in air, and consequently only a few of his films were metallic.

The facility with which metals volatilise under the "condensed spark treatment" varies very much, those of low atomic weights showing, as a rule, more resistance than the heavier metals to the action of the spark. According to Crookes, this power of resistance does not increase regularly as the atomic weight decreases. No relationship has yet been discovered between the degree of electrical volatility and any known constant. Some relationship might be discovered if the volatilisation were carried out under such conditions of temperature and pressure as would most likely ensure similar molecular conditions in each case. This might involve the melting point, as well as the atomic weight, as a factor.

If the order of the electrical volatility of the metals, as found by Crookes, be compared with Lothar Meyer's curve of atomic volumes, it will be found that the volatile metals lie at or near the minima of the curves, close together on the ascending sides in the periods iv., v., and vii., alternating from one to the other. Magnesium and aluminium, which are practically non-volatile, lie on the descending side of period iii. Aluminium, which is less difficult to volatilise than magnesium, is nearer the minimum of the curve. The metals given in the order of their electrical volatility alternate in the periods as follows:—

Metal.	Comparative electrical volatility (Crookes).	Period.
Palladium	108·00	v.
Gold	100·00	vii.
Silver	82·68	v.
Lead	75·04	vii.
Tin	56·96	v.
Platinum	44·00	vii.
Copper	40·24	iv.
Cadmium	31·99	v.
Nickel	10·99	iv.
Iridium	10·49	vii.
Iron	5·50	iv.

In a paper in which he discusses various properties of thin metallic films (*vide Am. Chem. Jour.*), xiv., No. 3, p. 185), Mr. Dudley gives some information respecting the colours of metals volatilised by the electric arc, much of which is not only interesting, but new, especially that which refers to the incandescent vapours of metals under volatilisation in the electric arc.

A GENERAL RELATION OF ELECTROMOTIVE FORCE TO EQUIVALENT VOLUME AND MOLECULAR VELOCITY OF SUBSTANCES.

THIS is the title of a paper by Dr. G. Gore, F.R.S., which has been reprinted from the *Proceedings of the Birmingham Philosophical Society*, Vol. viii., Part I. It is in continuation of those interesting researches which Dr. Gore has been carrying on for some time, and which have already borne fruit in the shape of at least two important papers, entitled (*a*) "The Relations of Volta-Electromotive Force to Latent Heat, &c., of Electrolytes," and (*b*) "A Method of Measuring Loss of Energy due to Chemical Union, &c.," both of which we have duly noticed in the pages of the ELECTRICAL REVIEW. The present paper occupies upwards of 70 pages, and we are indebted for it to the kindness of the author.

In this paper Dr. Gore has specially investigated the influence of *dilution*, and has ascertained the effects upon the mean amount of electromotive force of the voltaic couple:—1, of simple dilution of the electrolyte in water; 2, of liquefaction of the positive metal by mercury to form an amalgam; 3, of dilution of the amalgam by additional mercury; and from the results obtained Dr. Gore has been led to infer an explanation of the current. As the two most important substances in producing the current are the positive

metal and the negative constituent of the electrolyte, the investigation was chiefly confined to them; additional experiments were, however, made to ascertain the influence of liquefaction and dilution of the negative metal, of dilution of one solid metal by means of another, and of other circumstances, upon the *mean* amount of E.M.F. of the couple.

The method of examination employed was briefly as follows:—Measure the E.M.F. of a simple zinc-platinum voltaic couple, first in water alone; second, in a suitably dilute solution of the electrolytic substance; and third, in the mixture of the two. Multiply the E.M.F. of the couple in water by the weight of the water, and that of the undiluted aqueous solution by the weight of the solution; add the two products together and divide the sum by the total weights of the two liquids, in order to obtain the calculated *mean* amount of E.M.F. of the couple in the mixture. Subtract this amount from that obtained by experiment with the mixture (or the reverse, as the case may be), and the difference is the amount of gain (or loss) of *mean* amount of E.M.F. of the two mixed substances attending the dilution. The method adopted of measuring the E.M.F. was that of opposition and balance of the current from the voltaic couple by one from a thermo-electric pile of about 300 pairs of iron and German silver wires (see *Proc. Birm. Phil. Soc.*, Vol. iv., p. 130), with a suitable galvanometer in the circuit. A similar method was employed to ascertain the change of *mean* amount of E.M.F. caused by *liquefaction* of the positive metal in mercury, *i.e.*: 1. The E.M.F. of the solid metal with platinum in the given electrolyte was measured. 2. That of mercury with platinum was then found, and the mean amount of the two quantities calculated. 3. That of the amalgam with platinum was also measured. The method of ascertaining the effect of *dilution* of the positive metal amalgam was similar. In determining the effects of liquefaction and dilution of the negative metal by means of mercury the same method was used, a constant positive plate of zinc being employed. The same method which allows the measurement of the changes of mean amount of E.M.F., necessarily also enables us to examine, and in some degree to measure, the accompanying losses and gains of chemical energy; of freedom of molecular motion, &c., of electrolytes, metals, and amalgams; the degree of "dissociation" of electrolytes, &c.

The results will be more clearly understood if we carefully distinguish between several phenomena, viz.:

1. The production of a direct E.M.F. at the positive plate increasing the current.

2. The production of an E.M.F. at the negative plate, decreasing, or in some cases, reversing the current.

3. The loss of mean E.M.F. when chemical union has occurred between the constituents of the liquid, or between the two metals of an alloy when used as a positive plate.

The research is divided into six sections:—

(*a*) Influence of dilution of the electrolyte, using different halogens, acids, salts, and alkalies, and showing the rate of variation of *mean* amount of E.M.F. caused by the dilution; and the influence of chemical union and substitution, of varying the kind of negative metal, of the kind of solvent, and of temperature, upon the amount of effect of dilution. (*b*) Influence of dilution of the electrolyte, using different positive metals, negative metals, and electrolytes; effects of dilution at one metal only upon the actual and mean amount of E.M.F., and the influence of viscosity of the electrolyte upon the effects of dilution. (*c*) Influence of liquefaction of the positive metal by means of mercury, using different positive metals, negative ones, and electrolytes. (*d*) Influence of dilution of the positive amalgam, using different amalgams, electrolytes, and negative metals, and showing the rate of variation of *mean* amount of E.M.F. caused by the dilution. (*e*) Influence of liquefaction of the negative metal and of dilution of its amalgams, and (*f*) Influence of diluting one solid metal by means of another; relation of volta-electromotive force to equivalent volumes of elementary substances, &c.

The results under Section A are arranged in 15 tables, and include nearly 60 experiments. They show (1) that the amount of mean E.M.F. of the voltaic couple by dilution varies with the kind of electrolyte; (2) that it varies with the kind of negative metal, and (3) that the electro-negative constituent of the electrolyte has far greater influence than the electro-positive one upon the amount of change of E.M.F. produced by dilution.

The whole of the results under this section agree with the conclusion that dilution of an electrolyte increases the electromotive force and chemical energy of the substance diluted, and that this increase is due to greater freedom of motion of the molecules of the diluted substance.

Here we may remark that each of the molecules of a substance is supposed to vibrate like a pendulum, and its movements, therefore, obey the law of falling bodies; so that the larger the arc of vibration, the greater the fall, and the greater the velocity of motion.

(To be continued.)

THE TELEPHONE SYSTEM.

THE following Treasury Minute, dated May 23rd, 1892, upon the proposals for the development of the telephone system in the United Kingdom, has been issued as a Parliamentary paper:—

My Lords have before them the proposals of the Postmaster-General for carrying out the policy which has been adopted by her Majesty's Government for development of the telephone system in the United Kingdom.

1. It is the object of these proposals, while preserving the property in the telegraphs, which has been paid for by the nation, to secure that expansion of the telephone system which is called for by public opinion and the necessities of commerce. It is impossible to continue the present system under which the telegraph revenue is seriously suffering, while, on the other hand, the extension of telephones is checked in a manner which cannot be permanently maintained.

The proposals of the Postmaster-General will enable the telephone companies and the Post Office to co-operate in services to the public.

2. The telephone companies are at present restricted to oral communications. The scheme prepared by the Postmaster-General will in one direction, as hereafter explained, remove that restriction; and it proposes the establishment of trunk wires throughout the United Kingdom.

3. Unless trunk wires are in the hands of the State, a monopoly, injurious to the public interest, would inevitably ensue, to the advantage of the company which first laid down such trunk wires.

4. If, on the removal of the restriction to oral communications, the companies were allowed themselves to write down and deliver messages and a network of trunk wires were spread over the country, by private enterprise, the distinction, established by Mr. Fawcett, between the business of the companies and of the Post Office would disappear, and rival systems of telegraphy would be working side by side where Parliament intended that there should be only one.

5. For this reason it is proposed that the Post Office shall write down and deliver the messages, and that the Post Office shall provide a national system of trunk lines. United action on the part of the companies and the Post Office is necessary to the success of the scheme.

6. It is proposed that the companies should abandon their right to construct trunk wires, and that the Post Office should purchase from them such as they have already erected; and that in addition to this, the Post Office should gradually provide additional trunk wires, so that there may ultimately be a complete system of communication between all the important towns in the kingdom. It is further proposed that a connecting link between Great Britain and Ireland should be furnished by a submarine cable, and that the whole system should be open, not only to the subscribers of the companies, but also to any member of the public who may choose to come to a post office for the purpose of using it.

7. The companies will connect their exchanges with the offices of the Post Office, in order that their subscribers may telephone messages—

(*a*) For transmission over the public telegraphs.

(*b*) For transmission through the post as letters.

(*c*) For delivery as express letters.

(*d*) That they may call for the service of express messengers; and may

(*e*) Request to be placed in telephonic communication with other towns by means of the trunk wires of the State.

8. The Post Office will make no charge for the services of its officers who attend to the wires connecting the exchanges with the local post offices, and will pay the companies a commission of 5 per cent. on ordinary telegrams telephoned to those offices for transmission by the public telegraphs.

9. The Post Office will withdraw its veto on the establishment by the companies of public call offices in the houses and shops of sub-postmasters. It will further be a consideration whether, if the convenience of the Department will permit it, head, district, and branch post offices should be allowed to be used as call offices, &c., subject to such payment by way of rent as may be agreed on.

10. As far as practicable, the Post Office will provide underground wires at an agreed rent to connect together the exchanges of a company within one and the same exchange area, so that municipal authorities may not have to complain of their streets being disturbed by the companies, which, in some places, might be in competition.

11. The Post Office, where it can permit telephone companies to use railways, canals, or other property over which it has acquired exclusive rights of way for telegraphs, will charge a nominal sum of 1s. per mile of wire instead of 20s., as at present.

12. Parliament, by a Bill now about to be introduced, will be asked to confer on the companies, subject to the consent of the local authority, powers for the erection of the wires required to connect their exchanges with the houses of their subscribers.

13. The messages telephoned to post-offices for delivery will have to be limited in length, and it is proposed to adopt the two-fold limit of three minutes and 30 words. The charge will be the same as for an ordinary express letter—viz., 3d., if the address be within a mile of the post office where the message is written down.*

14. For conversations on the trunk wires of the State the following charges will, it is thought, be equitable, while, at the same time, sufficient to secure a margin of profit* :—For any distance not exceeding 20 miles, 3d.; for any distance exceeding 20 miles and not exceeding 40 miles, 6d.; for every additional 40 miles or fraction thereof, 6d.

15. A charge of 6d. for 40 miles has been sanctioned by the Treasury for the trunk wires already provided by the Post Office, but the charge of 3d. for 20 miles is new. The Post Office consider it necessary that there should be this lower charge for the short wires.

Longer distances cannot be charged for at a less rate, as, although it is true that the terminal expenses are a fixed quantity, the expenses of construction and maintenance will, even in proportion, increase greatly with the length of the line. Where a submarine cable is used, or where exceptional expense is incurred, an additional charge will be made.

16. As in the case of the London-Paris telephone line, the period of each conversation will be three minutes, and two consecutive periods will be allowed for a double payment.

17. My Lords will examine with care such schemes as may be successively submitted by the Post Office for the gradual construction of new trunk lines.

In the course of a few months wires can be erected on existing poles from London to certain principal places, and progress can be made as convenience permits with further wires in many directions.

These works would be carried out in such a manner as to supplement and extend the system acquired from the companies.

18. It must be clearly understood that the right of the Post Office to establish telephone exchanges, which was reserved by Mr. Fawcett, will be maintained, the Department holding itself ready, as in the past, to comply with the reasonable demand of any town or district for telephonic facilities.

19. As to fresh licenses, no further license for the whole country will be granted; and even for a license to establish an exchange in a particular town no application will be entertained unless a formal resolution in its favour has been passed by the corporation or other municipal authority, and evidence given that there is sufficient capital subscribed to carry out the undertaking. In this way competition will not be excluded, but a check will be imposed on the formation of companies whose sole object it is to force the existing licensees to buy them up.

But, although this is the policy which commends itself to Her Majesty's Government, it must be distinctly understood that, should licenses hereafter be granted on other principles, no company now or hereafter to be licensed will have any ground to complain of breach of contract or want of good faith on the part of the Postmaster-General.

It will be a condition of any license to a new company that their system must be constructed entirely of twin wires or metallic circuits, so that there may be an assurance of its efficiency.

20. The royalties now payable by the companies to the State will remain unchanged. The other conditions imposed by their licenses will remain unchanged, except so far as they may be modified by the policy indicated in this minute.

21. In conclusion, it may be stated that the intention is to meet, as far as possible, the views of municipal authorities, to aid the telephone companies in the improvement of their exchange system, to place additional facilities at the disposal of the public, and to establish trunk wires between the more important towns throughout the country.

My Lords concur.

Let a copy of this minute be laid before Parliament.

* These charges are independent of the charges which the companies make on their own account for sending a telephone message.

BREMEN ELECTRIC TRAMWAY.

OFFICIAL OPENING.

[FROM OUR SPECIAL CORRESPONDENT.]

THE Bremen Street Railway Company's electrical equipment, built according to the Thomson-Houston system, has been in successful operation since May 1st. On the occasion of the official opening festivities, on Saturday last, the road was seen under its ordinary normal conditions by fifty tramway people and city authorities, representing twenty-one different cities in Germany. The visitors were guests of the Union Elektricitäts Gesellschaft, of Berlin, the recently formed company which has taken over the business of the Thomson-Houston people in Germany and other countries of the Continent.

The Bremen road is the first operated in Germany on the well-known American overhead trolley system, and was in successful operation two years ago during the Bremen Exhibition. Since then the equipment has been extended, the company, on the basis of their exhibition experience, having since then obtained a concession to operate all their lines by the Thomson-Houston system. They have sold half their horses, and will dispose of all the rest as soon as the equipment of the remaining three kilometres of their line can be completed. Financially this road is an exception to the practice which up to now on the Continent has usually been followed, namely, that the Bremen Tramway Company gave a definite order for all the apparatus and equipment, and paid cash for the same without asking the electric company to take a financial interest or assume control of its operation. The power house, with plant, electric line equipment, with steel poles and motor trucks, cost about £21,000. The old car bodies and track were retained for the electric road. The steam plant is a noteworthy feature of the installation, the boilers being from Babcock & Wilcox, Glasgow, economisers from Green, and compound condensing engines from the American firm of MacIntosh & Seymour.

The cost for coal per car kilometre (cars carrying on an average a maximum load of 35 passengers) has been about $\frac{3}{10}$d. (2·5 pfennig) and recently even lower. The full quota of cars for which the equipment was calculated not being in operation yet, the power station is running under a light load, so that when the newly-ordered cars are put into operation the power costs will be still lower.

The day was enlivened with a banquet, attended by a liberal flow of that electric fluid for which Bremen has been for centuries famous, and without which no German assembly is up to candle-power,

LONDON CHAMBER OF COMMERCE.

THE annual meeting of the Electrical Trades Section of the London Chamber of Commerce was held on Friday last, May 27th, at the offices, Great Tower Street, for considering and discussing certain matters, as announced in our "Notes" columns last week. Mr. R. E. B. Crompton occupied the chair.

In opening the meeting, Mr. CROMPTON said that his first duty was to tell them that his period of office had come to an end, and he wished to state briefly the work that had been done during the last two years, and what still seemed to remain to be done. First, speaking generally, he could say that he thought they had reason to congratulate themselves on the success of the formation of the Electrical Trades Section. He thought it had to a certain extent promoted what it was intended to do, making a freer intercourse between the members of the electrical profession. They had met very frequently and discussed their matters of mutual interest, and that had been the means of their meeting elsewhere, and those who previously considered themselves trade rivals and hardly on speaking terms were now on much closer terms and had been able to work together in carrying out matters of any interest. He did not propose running through a list of the matters which had been undertaken by the section during the last two years, but he would point out one or two. Perhaps fortunately for themselves, having that section, but unfortunately from one point of view, the section had been in a position of antagonism with the Board of Trade. The questions arose out of the decision of the Board of Trade not to permit the use any longer of overhead wires. That decision appeared manifestly unjust. He (the speaker) was not one of those who upheld the use of overhead wires in crowded cities, but there was no doubt that in country places, where they had to be supplied with electrical energy, it was one of the methods which was necessary for distribution at a moderate cost. As a consequence of the Board of Trade's decision, they practically canvassed the whole section, and with the help of Mr. Murray and his staff they were able to put such a powerfully signed petition before the Board of Trade that they practically at once reconsidered their decision. He would not criticise the way in which they did that, but it was quite sufficient to say that they attained their object, and he did not think in future the trade would be treated in such a manner. There were one or two very important matters started last year which had not yet been carried through. He thought this was probably on account of the very happy state of trade—that was to say, that the most of them had been so busily employed that they had not had time to see to them. He alluded to the standardising of the machinery they used, in order to make machinery as interchangeable as possible. The only thing which had been practically carried out had been the standardising of the screws that they used in their machinery. That had been done, and certainly 98 per cent. of the electrical manufacturers were using the one screw which was proposed a few years ago by the Small Screw Committee of the British Association, and it was now, therefore, practically universal in England. It was interchangeable with the Swiss screw thread, and they might say that it was practically international. The two other matters he would allude to were that by means of Mr. Murray's staff those who wished to visit the Frankfort Exhibition had been able to do so in a body, and he thought they had derived some small advantages from that course. They were treated exceedingly well and hospitably by the Committee of Management at the exhibition. Another point was in persuading the directorate of the Crystal Palace Exhibition to postpone the exhibition. If they had stuck to what was first intended, it would not have been the success that it had been. The display, as it was, really only reached full form by the middle of February, and that was four months later than the date originally proposed by the Crystal Palace Executive. He thought that showed they were right in their decision. The burning matters which were still before them were the question of the telephones and the telephone service of London and England, and how far the interests of the telephone companies, and those of the heavier electric industries, could be brought together so as not to clash in certain respects. It appeared at present as if those interests did clash, and it would be a great pity if a great deal of money was expended on law, if those questions could be settled by friendly meetings between the representatives of the different interests. A great deal had been done on the Continent of Europe in that respect, and he thought that he might suggest to those who followed him (the chairman) that if they could but have before them the idea of some such congress to settle that matter as was carried on at Frankfort last year, it might save money, temper, and the patience of all concerned, very greatly. He must here grant a tribute for the extreme courtesy which had been shown to him and those who represented the heavier side of electrical engineering, by the telephone company in the person of Col. Jackson. He had only to say that he left the office of chairman, which he had filled for much longer than he originally intended, hoping that it would be as pleasing a duty for his followers to serve them as it had been for himself.

Col. JACKSON stated that the next subject was for the appointment of chairman and vice-chairman of the section. They had observed the manner in which Mr. Crompton had presided over the section, the skill with which he had wrought the different work which the section had had brought before it, and the devotion which he had always given to the section. He thought they would agree that the right thing for the section to do was to ask him to place his services at the disposal of the section for another year. That was his proposal to the section

The SECONDER of this resolution said that he thought they must be more than satisfied with the results which had been attained by Mr. Crompton and the committee which had been working with him.

Colonel JACKSON proceeded to put this to the meeting, but

Mr. CROMPTON stated that he fully appreciated their great kindness, but it was quite impossible that he could continue in the office; there were many reasons why it was quite desirable there should be a change. He was rather an overworked man at the present time, and it was a feeling of great annoyance to him that he had not lately been able to give the section half the time that it deserved, and he could fill the whole time if he continued in his present position. He was not doing justice to his own business or to the work of the section. He had considered the matter very carefully, and he thanked them for proposing that he should continue, but his decision was irrevocable.

Mr. EMILE GARCKE said that it might be convenient, perhaps, in support of Colonel Jackson and the seconder's remarks, if he said that they had exercised all their powers to persuade Mr. Crompton to withdraw his resignation, but they had not been successful. They therefore received his resignation with very deep and sincere regret. He thought it was the rule with other sections of the Chamber that chairman and vice-chairman should be elected over two years, and he suggested that they should do the same. The number of meetings which had been held by the section was no means of measuring the work which the chairman had done. In the matter of overhead wires a great deal of anxiety and trouble was incurred, and the negotiations with the Board of Trade were of such a character that they had to meet very frequently, and it was not practical to meet the section at every point to confer with them. He then moved that they appoint Major Flood Page as Mr. Crompton's successor.

Mr. MUSGRAVE HEAPHY seconded the motion, which was unanimously carried.

It was next proposed by Mr. ERSKINE, seconded by Mr. EDMUNDS, and carried, that Mr. Emile Garcke be elected vice-chairman in the office made vacant by Major Page's election as chairman.

The chair was then taken by

Major FLOOD PAGE, who stated that no one in the room regretted more cordially than he did that Mr. Crompton should vacate the chair. When the electrical section was constituted, he himself proposed Mr. Crompton as chairman, and they had an unanimous vote. The position the section had taken he conceived to be mainly due to the position of Mr. Crompton in the electrical world. He rose to propose a second deputy chairman, and as he thought it was very important that they should have all interests represented in the section, he therefore proposed Colonel Raynsford Jackson. They would have a great deal to do with the telephone question in time to come.

This having been seconded,

Colonel JACKSON thanked them for their proposal, but he begged to decline for several reasons.

Mr. ALEXANDER SIEMENS stated that it would be a great thing for the section to have Colonel Jackson for a second chairman, and Major Page requested Colonel Jackson to reconsider it, but he definitely declined.

Mr. A. R. BENNETT proposed that Mr. Alexander Siemens be deputy chairman.

This having been seconded, it was put to the meeting and unanimously agreed to.

Major FLOOD PAGE thanked them for the honour they had done him. He could not pretend to hold the same position in the electrical world as Mr. Crompton occupied, as he was thoroughly versed with the scientific aspect of the question, as well as the commercial, while he (Major Page) simply represented the commercial aspect of electricity. He said he would do his best for the two years to keep the section alive, and do what he could. Their next business was to consider the desirability, or otherwise, of the section following the precedent of other sections of the Chamber, in convening the whole of the membership of the section to all future meetings, appointing special committees to deal with special subjects.

Mr. SIEMENS proposed, Mr. BOWMAN seconded, and it was agreed that the section follow the precedent of the other sections.

The next business was to consider the attitude of the electrical trade towards the Chicago Exhibition.

Mr. KENRICK B. MURRAY reported that the English Royal Commission, which had been organised to promote the interests of the British exhibitors at the Chicago Exhibition, had requested the London Chamber to act as the London committee. They had accepted that duty, and, under ordinary circumstances, would have requested the electrical section to consider whether it would take any steps to be represented at Chicago; but he understood that Mr. Preece, of the Post Office, had been occupying himself specially with that question, and perhaps it was not desirable that they should in any way appear to be interfering with his action.

Mr. ALEX. SIEMENS proposed "That a special committee be appointed to report to the section, after conferring with Mr. Preece and others, what attitude they recommend the electrical section to take with regard to the Chicago Exhibition. The committee to consist of Messrs. Ravenshaw, Albright, and Wharton, and the chairman."

Mr. EMILE GARCKE seconded this, and it was carried.

The telephone question was the next subject for consideration. Nothing further had been done since the Chamber went up with a deputation to the Postmaster-General.

Colonel JACKSON had a few observations to make. They were all aware that there was a telephone association for the protection of telephone subscribers, which professed to be affiliated with the Chamber of Commerce, but a circular which had been issued by that association would show that it could not properly be affiliated with the Chamber. It had entered into arrangements with the New Telephone Company, and it had converted itself into a body of canvassers for subscribers for that company, and it secured to the members of the association special privileges which were to be denied to the general public, because it expressly stipulated that no others should have the special privileges offered to and agreed to be given to the members of the association. He thought it was impossible for an impartial body like a Chamber of Commerce to have affiliated

with it an association which was practically nothing more nor less than a canvassing body seeking advantages for the members of the association at the expense of others, canvassing to assist one telephone company and in opposition to another. He then read several portions of the circular. It was not necessary for him to say more upon this subject; it was quite clear to him that such an association could not be legitimately affiliated with the Chamber.

The CHAIRMAN stated that the Committee of the Chamber had complained to that association of the use that had been made of the name of the Chamber, and they had promised to withdraw all such use in future circulars.

Mr. A. R. BENNETT, in the course of some remarks, stated that he thought Colonel Jackson had over-stated the facts.

After some discussion, in which Mr. MORSE, Mr. A. R. BENNETT, Mr. ALFRED THOMSON and Mr. HAIGH took part,

Colonel JACKSON moved a resolution that, "Considering that the Telephone Subscribers Association have undertaken a task for the consideration of canvassing for subscribers for the New Telephone Company, they should not be affiliated with the London Chamber of Commerce."

This was seconded, when

Mr. A. THOMPSON moved an amendment that no action be taken in the matter for the present.

Mr. ALBRIGHT seconded this, and on the amendment being put to the meeting the votings were ten in favour and seven against, so that Col. Jackson's original motion was lost, while the amendment was carried.

Col. JACKSON intimated his intention of bringing the matter before the Council of the Chamber.

Major FLOOD PAGE stated that the next business was the attitude towards the Parliamentary Committee to consider the question of electrical railways in London. He thought that was practically passed; all the schemes had been passed, and they had nothing to do but to say "thank you."

The next business was the action taken by the Chamber in reference to the question of overhead wires, and to consider the reply of the President of the Board of Trade.

Mr. MURRAY read the correspondence which had taken place with the Board of Trade on the subject of overhead wires.

Mr. CROMPTON said that the reply of the Board of Trade, if taken exactly as written, would put them in a rather foolish position. It would appear as if they had been at great pains in preparing a memorial without any due cause for such. He thought that they need not say anything more about that matter. They had what they wanted for the present. He wished to say something on this matter merely to show that they did not proceed without giving the matter due justification.

The CHAIRMAN stated that the next matter for consideration was the bye-laws of the London County Council in reference to overhead wires.

Mr. GAINE stated that the bye-laws have been made by the London County Council, but were of no force until they were formed by the Board of Trade. The Board of Trade had made an appointment to consider them, and the objections of all parties, on June 20th. The interference of the County Council was a very large public question, and he suggested that a small committee of the section be appointed for the purpose of considering the bye-lays, and also of hearing those whose interests were affected, and the public necessity generally; because it might be in the interests of the public, and that was what he looked upon as the interests of the Chamber.

Mr. A. R. BENNETT seconded this proposal, which was carried. The committee appointed consists of Mr. Gaine, Mr. A. R. Bennett, and Mr. Edmunds.

Regarding the electrical communication on the coasts, the CHAIRMAN said that the President of the Board of Trade, Sir Michael Hicks Beach, had the matter in hand, and there was practically nothing that they could do in the matter at the moment.

Major FLOOD-PAGE said that he was informed that the new Mining Section was a very large and important section, and he understood it was a kind of token of goodwill, a kind of introduction to that section, that when matters arose that they should meet in cordial friendship.

Mr. MORSE proposed—"That a special committee be appointed to consider and deal with the question in regard to electrical traction, and to report from time to time."

This was seconded by Mr. GARCKE, and carried unanimously, after lengthy discussion.

Mr. A. THOMPSON moved an addition to the resolution that the chairman and vice-chairman be the committee, with power to add to their number, the names so added to be submitted to the next meeting.

Mr. BOWMAN seconded.

Mr. CROMPTON moved an amendment that the committee be nominated forthwith by the chairman and vice-chairman. This was seconded, and on the motion being put to the meeting Mr. Thompson's amendment was lost.

A vote of thanks to the Chairman terminated the proceedings.

LEGAL.

Akers v. Iliffe.—On Tuesday last, the case of Akers *v.* Iliffe came before Justices Mathew and Wright, sitting as a Divisional Court in the Queen's Bench Divisicn. This was the appeal of the defendant from Justice Denman, who refused to order the plaintiff to answer certain interrogatories.

Mr. Isaacs, for the defendant, supported the appeal; Mr. Frank Gover represented the plaintiff, and opposed the appeal.

Mr. ISAACS said the plaintiff brought the action to recover damages for alleged fraudulent representations in connection with the sale of an electrical business formerly carried on by the defendant for the sum of £5,000.

The PLAINTIFF said he was induced to purchase the business by the false and fraudulent misrepresentations of a Mr. Moat, who, he said, acted as the defendant's agent. The misrepresentations he complained of were that the business at Prince's Street was separate and distinct from another business carried on by defendant at Chalk Farm; that the net profits for the year 1890 amounted to £2,442, and that the business was an increasing one. Further, the plaintiff alleged that the defendant adopted and affirmed the representations of Mr. Moat, and that the representations amounted to a warranty. By his pleadings to the action the defendant denied that the representations were made, or that Mr. Moat acted as agent for him, or that he adopted and affirmed the statements of Mr. Moat.

The defendant's appeal was then dismissed, with costs.

Action against the National Electric Supply Company.—On Wednesday, in the Court of Queen's Bench, before Mr. Justice Day, sitting without a jury, Messrs. Clough & Co., a firm of accountants of London and Leeds, sued the National Electric Supply Company, Limited, of Preston, to recover £121 17s. 2d. for auditing the accounts of the company and negotiating a loan of £3,000 upon debentures of the company. The defendants paid £70 into court in satisfaction of the claim, and repudiated any agreement to pay the plaintiffs £50 for negotiating the loan. At the close of the evidence Mr. Justice Day gave judgment for the plaintiffs for the full amount claimed, with costs.

THE TELEPHONE AND THE GOVERNMENT.

THE proposals of the Postmaster-General for the development of the telephone system have been placed before the Lords of the Treasury, who have issued a minute upon the subject with instructions that it shall be laid before Parliament. The minute has been issued as a parliamentary paper, and is published in full in another column.

The objects sought in these proposals are to "safeguard the national property in the telegraphs," and "to secure that expansion of the telephone system which is called for by public opinion and the necessities of commerce." The telegraph revenue is said to be seriously suffering, and the extension of telephones checked, so that it is impossible to continue the present system, whilst the new system "will enable the telephone companies and the Post Office to co-operate in services to the public."

The principal changes involved in the proposals are:—That the telephone companies which are at present restricted to oral communications will be permitted to transmit written messages not exceeding 30 words to post offices for delivery by postal officials; the permission to run trunk wires now held by telephone companies to be withdrawn; trunk lines now belonging to the companies to be purchased by the Government; new trunk lines to be gradually established by the Post Office after careful examination by the Treasury; telephone companies' exchanges to be connected with the post offices in order that their subscribers may telephone messages for delivery by telegraph, post, express, for attendance of express messenger, and for telephonic communication with other towns; telephone call offices to be permitted in sub-post offices and if possible, in head, district and branch offices; the establishment by the Post Office, at an agreed rental, of underground wires to connect exchanges of a company within one area; the reduction to 1s. per mile for rights of way over railways—present rate being 20s.; Government to ask Parliament to confer on companies powers for erection of exchange wires; any license hereafter to be granted for a limited area only, after formal resolution by local authority, production of evidence of the possession of sufficient capital to carry out the undertaking, and upon condition of metallic circuits being used.

As the intentions are to safeguard the national revenue in the telegraphs, to place additional facilities at the disposal of the public, and to aid the telephone companies in the improvement of their exchange systems, the proposals may conveniently be considered from those points of view.

The Treasury minute states that the telegraph revenue is seriously suffering. It would be of interest to know by what method of computation the deficiency is shown; whether it arises by taking the total revenue, or from a comparison of

actual telegraph receipts at different periods. The consideration is not without importance. When the Government licensed private persons to undertake telephonic exchange communication, they stipulated for one-tenth of the amount charged for such communication. Was this to be regarded as an entirely new source of revenue, or as an equivalent for any loss that might be sustained to the Telegraph Department? As far as can be judged from the Postmaster-General's recent statement in Parliament, it would seem that telephonic communications over short distances are not regarded as inimical to the interests of the Department, whilst those over long distances are. It follows that the proceeds of telephonic licenses over short distances are a source of new revenue to the Department, and those over long distances are an equivalent for the loss of revenue from telegraphic messages which might, could, or would have been sent through the Departmental channels, if the telephonic line did not exist.

It must not be forgotten that the telephone has been no expense to the Government. They paid nothing for it. That in no way reduces their right to control it, but it affects the question of the revenue which they are justified in expecting from it, and it would be instructive to know whether the present proceeds from the telegraphs combined with the receipts from telephonic licenses are above or below the telegraphic revenue of previous years, when a proper percentage has been added as an allowance for the natural increase which might have been expected in the volume of business. It is not sufficient to say that the revenue from the transmission of telegraphic messages now is less than it was in some previous year, and ascribing the loss to the telephone without also taking into account the revenue which has accrued from the telephone.

Whilst the Government proposals will meet with general approval in so far as they are intended to protect the revenue of the Department, it will undoubtedly be considered that the protection should not involve any hindrances to telephonic communication.

The concessions which provide any new facilities to the public may be divided into those which become operative now and those which depend upon some future developments to be operative at all. The postal call offices and the permission to telephone messages are practically the only ones of immediate value. The royalties are not reduced; the rates for trunk line communication are not any lower than we believe at present exist, if, in fact, they are as low.

The telephonic transmission of messages to and from the telegraph offices is a system which has been in use in most countries except our own for some years past. It is, we believe, generally regarded as a convenience to the Telegraph Department rather than a concession to the telephone suppliers. Convenient as it may be to occasionally transmit an oral message to be subsequently written, we do not regard the restriction to oral communications as at all a hardship to the telephone companies, or a serious inconvenience to the public. We believe that the time will come when it will be seen to be a serious mistake to burden telephone exchange or trunk lines with "slow" messages, as now contemplated.

It is in section 7, sub-section (*e*), that the most important proposal is to be found:—"The companies will connect their exchanges with the offices of the Post Office, in order that their subscribers may request to be placed in telephonic communication with other towns by means of the trunk wires of the State." This is one of the concessions which depend upon future developments to render any increased facility to the public.

To obtain communication with another in a distant town by means of the trunk wires of the State is apparently an extremely simple matter. To read the Treasury minute, one would hardly suppose that it bristles with difficulties—practical, economic, and ethical. To take an existing case, an exchange in Liverpool and another in Manchester belong to the same company; their subscribers' lines and their trunk lines terminate at the same places. To connect a Manchester subscriber to a Liverpool subscriber is almost as easy as to connect two Manchester subscribers. On the system of the Postmaster-General, the trunk lines will terminate at the Post Office. They cannot well be allowed to remain under a company's roof, since they may be required to transmit the messages of a competing company. The procedure in future, therefore—if the proposals are carried through—will be to establish a foreign authority between the subscribers of the same company, necessitating additional and very undesirable operations at each end of the line. This must be the case when the subscribers in the respective towns belong to the same company. What is to happen when they belong to different companies we cannot suggest, but we are sure that in supporting their proposals the Conservative Government will need to make some radical changes in what is generally considered reasonable or fair. It is not easy to observe from the minute—any more than it was from the speech of the Postmaster-General—whether it is contemplated to give the subscribers of one company facilities over the lines of another company, or how the matter will be arranged, but when the necessary links exist, an effort will certainly be made to carry the communication into effect. Upon what terms, consistent with fairness, can such communication be given? There is no doubt whatever that it would be a great convenience to the section of the public who are not shareholders of existing telephone companies that they should, when subscribers to a company with, say, three subscribers, have the means of communicating with the subscribers of a company which number 3,000. But there are grave doubts as to the public policy of compulsorily carrying such an arrangement into effect. There is no doubt that it would be deemed very satisfactory by one section of the public if the accumulated riches of another section of the public were to be thrown open to them.

The possession of the trunk lines by the Post Office will involve very many practical difficulties. It can in no way confer any advantages on subscribers to a company having exchanges at each end. It can only be of public advantage by being the medium of communication between the subscribers of exchanges belonging to rival companies, and an equitable arrangement for such communication is an almost impossible thing to devise.

The Treasury are of opinion that "unless trunk wires are in the hands of the State, a monopoly injurious to the public interest would inevitably ensue to the advantage of the company which first laid down such trunk wires."

The terms upon which existing trunk wires are to be obtained are not stated. If the companies owning them choose to surrender the advantages which they confer for a monetary consideration, there can be no cause for complaint elsewhere; but compulsory purchase or inadequate compensation will certainly be an unfair exercise of Governmental powers. The lines have been constructed by the companies with the permission of the Department, and the public have received any benefits which the lines have conferred in consequence of a justifiable reliance on that permission, granted so far as we are aware, unaccompanied by any intimation that it would be subject to sudden revocation without notice, and we believe that the carrying out of the Government proposals in this respect, except on such terms as may meet with the approval of the companies, will be a check on enterprise, and give rise to such a want of reliance on Governmental good faith as will be far more "injurious to the public interest" than the retention of trunk wires by any company which may happen to have them.

Indeed, it is difficult to understand why the Government should so strenuously insist on the necessity of acquiring and controlling trunk wires. According to the Treasury minute, "in the course of a few months wires can be erected on existing poles from London to certain principal places, and progress can be made, as convenience permits, with further wires in many directions." The Post Office has in some places competed with its licensees in local exchanges. In pursuance of the same policy we see no reason at all why the Post Office should not extend its competition to trunk wires, and afford the means of communication over those trunk wires to any telephone subscribers who desire to avail themselves of the facilities. If this should still afford the existing companies an advantage, as indeed we believe it would, we see no equitable method of avoiding it. The Post Office and its associated exchanges should pursue their policy with confidence, and await the time which may be necessary to build up a business of their own from which to reap the reward of their enterprise or incur the risks which they might have run.

The acquisition of the trunk lines is regarded as necessary because "if the companies were allowed themselves

to write down and deliver messages and a network of trunk wires were spread over the country by private enterprise . . . . rival systems of telegraphy would be working side by side where Parliament intended there should be only one." Withdraw the reason and the necessity no longer exists. The permission to deliver written messages is given by the minute, and the acquisition of the trunk lines is a consequence thereof. When the nature of telephonic communication is more generally understood it will be found that trunk lines under the control of the organisation owning or controlling the terminal stations is far more to the public advantage than the permission to deliver written messages. If the public cannot have both the public should choose that which is more directly suited to the service.

On almost any ground touched upon the difficulty of the question is shown. One of the main reasons urged in Parliament for the Government proposals was that the public were to have the blessings of competition, and the Treasury minute shows a distinct tendency to discourage such competition. "No further license for the whole country will be granted, and even for a license to establish an exchange in a particular town no application will be entertained unless a formal resolution in its favour has been passed by the corporation or other municipal authority, and evidence given that there is sufficient capital subscribed to carry out the undertaking." Why? Because "a check will be imposed on the formation of companies whose sole object it is to force the existing licensee to buy them up." The Government are justified in taking care that their licensees are able to pay their royalties, it might be very desirable if they could also ensure the genuineness of applications and the certainty of the licenses being genuinely worked; but how can they possibly carry out the principle of grandmotherly care involved in such conditions. The very effort which they make to prevent it may be the cause of its being carried into effect. The Government desire that the public shall have the benefit of competition, but the Government propose to discriminate between those who may apply for licenses. A sort of "Local Option," not permitted in other affairs, is to be permitted in telephones. Much is to be said for this "local option," but what does its application mean? That the Government itself converts into a monopoly any existing telephone exchange, the proprietors of which can persuade the local authority that their system is ample for the locality's needs.

It is the almost inevitable result of such interferences that they defeat their own object, and they can never be carried far enough. The present proposals of the Treasury do not provide for a contingency which is more likely to exist with the limitation proposed. Where two telephone services exist, the subscribers are divided into two classes—those who pay two subscriptions and have a double service, and those who have only one. It might be convenient and profitable to have the outward semblance of opposition, though the ownership be the same. The Treasury makes no provision for any such eventuality, which it certainly must do if it begins to provide for the prevention of companies being started for the purpose of being bought up. In fact it is not possible for the Government to provide for all eventualities, and probably the safest way is not to begin. Affairs left to private enterprise have a way of settling themselves, and we hold that all the Government can consistently do is to make sure, as any business firm would do, that the licensee is in a position to pay the royalties upon which the retention of his license depends, and leave the rest to the natural course of events.

It has been suggested that the proposals of the Government, apart from the objects stated, have in view the depreciation of existing telephone properties in the event of future purchase being desirable. We mention this only to show that the Government proposals themselves prove the contrary. There is no certainty that any new organisations will depreciate the value of the old. They certainly will not without enhancing their own, and in the event of future purchase the Government would have to pay with one hand what it saved with the other, and would, besides, be put to very considerable expense in consolidating and renewing the exchanges which are to be encouraged to start.

It seems to us that the proposals are not well designed to increase the telegraph revenue, except by increasing the telephone charges to the public; that the additional facilities offered to the public are unimportant, except where they are unfair; and that instead of aiding the telephone companies in the improvement of their exchange systems, they will, on the contrary, hamper them with restrictions, and result in public inconvenience through divided authorities. The apparent advantages to the public almost entirely depend upon eventualities which are merely speculative and may never arise, but which the Treasury seem to take for granted.

NOTES.

Royal Society.—The following papers were down for reading, last night (June 2nd). The election of fellows was also announced. Lord Kelvin, P.R.S.: "On a new form of air-Leyden, with application to the measurement of small electrostatic capacities." Dr. J. Larmor: "On the theory of electro-dynamics as affected by the nature of the mechanical stresses in excited dielectrics. Major Hippisley: "On current curves."

British Association for the Advancement of Science.—The next annual meeting will be held at Edinburgh, commencing on Wednesday, August 3rd. The President elect is Sir Archibald Geikie, LL.D., D.Sc., For. Sec. R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom, Corresponding Member of the Institute of France. Information about local arrangements may be obtained from the Local Secretaries, Edinburgh.

Electric Lighting of War Vessels.—The *Resolution*, one of the first-class battleships provided for by the Naval Defence Act of 1889, was launched on May 28th, at Jarrow, from the yard of the Palmer Shipbuilding and Iron Company. The vessel will be lighted throughout by electricity, with 700 lamps. There will also be four search lights each of 25,000 C.P.

Chester and the Electric Light.—Dr. E. Hopkinson, of Manchester, last week met a number of members of the Chester Watch Committee with reference to the introduction of the electric light. Several of the sites suggested for a station at which to generate the electric light were visited, and Dr. Hopkinson will shortly make his report as to which site he considers best.

The Electric Light at Portsmouth.—Immediately upon the receipt of the necessary authority for borrowing money, the Electric Lighting Committee will take action for the purpose of carrying out Prof. Garnett's scheme, which includes the lighting of the sea front. A new floating bridge, to ply between Portsmouth and Gosport, is to be furnished with an installation of electric light.

Electric Chimes.—The *Scientific American* for May 21st contains an interesting description of an electric chiming apparatus, such as could be made by an amateur of fair skill who is accustomed to and has the use of tools. The controlling mechanism consists of a perforated band of paper passing under brushes in the usual manner, the band being driven by a small electro-motor. When attached to a clock a contact arrangement is provided for starting the mechanism.

Electric Tramway Accident at Birmingham.—An enquiry was held last week at Birmingham, as to the full cause of the death of a child two years of age. The little girl lost her life by being run over by an electric tramcar. From the evidence given by different witnesses, it is clearly proved that no blame was due to the Central Tramway Company, who had had their trams fitted with the obstruction remover or "life-guard" as required by the Board of Trade regulations. A verdict of accidental death was given. It seems a great pity that so young a child should have been allowed to play in a busy public thoroughfare without protection. Such cases are likely to prejudice the minds of the community against electric traction, whereas the fault lies entirely with the sufferers and not in the least degree with the electric companies.

The Pondroux Battery.—This battery, which was shown at the last Exhibition of the Société Française de Physique is said to be specially suitable for small electric light installations. The exciting liquid is a solution of chlorhydrate of ammonia mixed with an equal weight of azotate of soda or potash (100 grammes of each salt to 1 litre of water). The depolariser consists of 150 grammes bichromate of potash or soda, 200 grammes sulphuric acid, and 1 litre of water. The battery itself is formed of a number of concentric cylinders of zinc and carbon and a corresponding number of concentric porous pots one inside the other. According to the inventor the kilowatt hour from this battery costs 5 francs; far too much!

An Electrolytic Experiment.—Mr. J. T. Sprague has written to a contemporary regarding an experiment which was said to be due to Herr Arons. It is the rotation of a copper cylinder, under the influence of electrolysis, dissolving one side and depositing on the other. It seems that the experiment was discovered by Mr. Sprague and patented in 1881 (No. 4,454) in which specification he described a meter working on that principle. Many years earlier than this he had discovered the fact and used it experimentally in the form of a disc rotating in the same manner between two electrodes. "Doubtless," says Mr. Sprague, "Herr Arons discovered this for himself, but, none the less, the discovery is not 'due' to him."

Another Electrical Method of Producing Ozone.—We have noticed several new methods lately for producing ozone from the atmosphere by means of electricity. A recently published process by two Dutchmen, A. Schneller and W. J. Wisse, possesses at least one novel feature. There is a so-called ozonising chamber in their apparatus which is fitted with a number of electrodes enclosed in tubes of glass or other good dielectric material. These electrodes are alternately + and −, but they are joined up to a transformer or alternating current dynamo giving a large electromotive force, and their polarity is perpetually changing. The apparatus includes an arrangement for freeing the air of dust and moisture before it is allowed to pass into the ozonising chamber.

The Electrolytic Treatment of Cuprous Liquors.—There are few chemical works that are not unencumbered with waste of various kinds; for in these days, when money is sometimes literally to be coined out of odds and ends, or, to be less sanguine, when profits are to be saved by a skilful manipulation of bye-products, nothing is thrown away. A recent application of electrolysis saves a great deal of the copper that used to be wasted through those who roast and lixiviate copper pyrites, &c., not knowing how to utilise the crude cuprous solutions that are obtained during the processes. The application is due to C. Höpfner, of Giessen. The crude solution is first converted into a mixture of cupric chloride and sodium sulphate by the addition either of common salt or copper sulphate. The copper is then precipitated as cuprous chloride by heating the liquor with metallic copper, silver being precipitated as metal at the same time. The liquor now contains only sodium sulphate, together with traces of other metals, *e.g.*, iron, nickel, &c. If it is worth while, these metals can be precipitated by any well-known chemical process, and the liquor then treated for the separation of "Glauber's salts." If the original liquor is acid, it is first neutralised by the addition of cuprous or cupric oxide. Cuprous sulphide, oxide, or carbonate, can be used instead of metallic copper for precipitating the metal from the cupric chloride solution. In this case iron, manganese, and other metals are also thrown down. The necessary cuprous oxide is obtained by treating cuprous chloride with caustic lime. The copper precipitate, which may now contain metallic copper, cuprous and cupric oxides, and cuprous chloride, is next dissolved in a neutral or alkaline solution of some chloride which will dissolve cuprous chloride, such as sodium, potassium, cupric or cuprous chloride, when silver, bismuth, arsenic, and antimony are left behind as metal, or in a state of oxidation. Metallic copper is obtained in a state of purity from the solution by electrolysis. As the oxidation and chlorination of pyrites by reacting is often incomplete, it is advisable to separate magnetic pyrites from the roasted mass by means of magnets before leaching, and to submit them to a separate treatment.

The late Mr. Willans.—The following letter dated May 24th appeared in last week's *Engineering*:—"Strangely enough yesterday afternoon I was discussing (with a well-known English engineer who has given the subject of condensation in steam engine cylinders his special and experimental attention) the subject of Mr. Peter Willans, the beautiful conception of his engine and the probable time absorbed in its development and perfection. To-day one reads of his accidental and terribly sudden death. Only a short time since I had a letter from him in which he stated that he intended to determine by experimental investigation the *rate of piston speed* at which the jacketing of cylinders *began to prove* beneficial. Poor Willans! After years of patient and scholarly investigation, he had produced an engine that as it were filled up the position prepared for it, beside the modern dynamo; and now when his creation was acknowledged on all hands to be a triumph of mechanical ingenuity, and the reward was coming upon him, to be cut down so ruthlessly, is sad indeed. The results of his researches and investigations published in and adorning the literature of the Institution of Civil Engineers, will undoubtedly become classic. They are worthy of the best experimental masters and investigators from the Ecole de Mines. There is no doubt but that we have lost an investigator who, had he lived, would have left little margin, either for improvement in the steam engine, or in the space to be filled in the knowledge of the physics of steam as a motor agent, and in the thermo-dynamic problems involved.—B. H. Thwaite."

Electrical Conductivity—a Delicate Test.—In cases of delicate measurement, the application of electricity has for some time been regarded as *facile princeps*. The beauty of this application is well illustrated in some recent experiments on the solubility of glass in cold water by F. Kohlrausch. The solubility of various kinds of glass was determined by measuring the electrical conductivity of the solutions obtained on treating the glass with distilled water at 18° Centigrade. Most people would have imagined that glass is a substance entirely insoluble in cold water, but the delicate method of measurement employed sufficiently demonstrated that a solvent action does take place except in the case of the best kinds of glass. The curious fact was elicited that of two solutions prepared under similar conditions from two kinds of glass having approximately the same composition, the one may have almost twice the conductivity of the other; it is suggested that this result may be due to the two samples having undergone different treatment in their manufacture. Kohlrausch points out that the best and most rapid test for inorganic salts in distilled water is a measurement of its electrical conductivity; the presence of carbonic anhydride it seems, may be determined by the same method.

Mons. Gouy's Experiments on Contact Differences of Potential.—In our issue for February 19th, we described some experiments conducted by Mons. Gouy, of the Paris Academy of Science, and gave the conclusions which were deduced by him from these experiments. These conclusions, however, were the subject of somewhat severe criticism by Mons. Pellat at a meeting of the Academy a short time ago. [Vide *Comptes Rendus*, Vol. cxiv., No. 4, pp. 164, 165.] It may be remembered that Mons. Gouy interpreted his electro-capillary experiments as indicating that the actual difference of potential between mercury and a metal would be either nil, or very small. This conclusion being in opposition to that deduced by Mons. Pellat in a previous research, the latter now offers his objection to it. Gouy stated that amalgams containing $\frac{1}{1000}$th of the metals amalgamated, behave in a voltaic pile, just like the metals themselves do. Pellat came to this conclusion in the case of zinc and cadmium amalgams, but holds that it should be otherwise with amalgams of metals which, like silver and gold, form the cathode in a liquid. He argues that under the conditions in which Mons. Gouy made his observations, all his amalgams, excepting the amalgam with "darcet" alloy, for which the law is wrong, ought to behave in a cell like mercury, and not like the amalgamated metal. He also goes so far as to say that nothing of any value can be deduced from these experiments, as far as the true difference of potential of the metal and the mercury is concerned. Meanwhile Mons. Gouy has, up to the present, left Mons. Pellat's criticism severely alone.

The Magnetic Ores of Ashe County, N.C.—These magnetic iron ore deposits formed the subject of a paper by H. B. C. Nitze, at a meeting of the American Institute of Mining Engineers, held a few weeks ago at Baltimore. These deposits, situated in an area of crystalline rocks, and embracing an extent of 150 square miles, are practically undeveloped, though some small prospecting has been carried on, and one small Catalan forge, making a very superior tough iron, is in operation. The ores are for the most part magnetites, and these are suitable for the manufacture of Bessemer pig iron, though hematites and red specular ores are also found. Ashe County contains three main ore belts; one of these show thick beds of magnetite running from 41·36 per cent. metallic iron to 60·48 per cent., and extremely low in phosphores and sulphur, but high in silica; the second belt has been traced over unopened ground by the dipping needle, whilst the third contains titanic acid (8·8 to 9·7 per cent.), which condemns it for blast furnace use.

A "Have."—We clip the following from the Queensland *Electric Teleyraph Gazette*:—

"Are you the bloke," the stranger said,
"As took this tillygrim?"
The clerk looked up and shook his head,
And took "the wire" from him.

The old man's voice was slow and sad,
With grief his eye was dim;
"It comed from Jake, and I'm his dad;
You sure it comed from 'im?"

"If he writ that, he's larnt to write,
And larnt it lately too;
Tho' them here words he sends ain't quite
What my young Jake 'ud do."

"You see it's sharp, and pinted, and
Unlike my little b'y!"
The old man trembled lip and hand,
And wiped his rheumy eye.

The clerk rejoined, "Oh, that's all right,
Be calm, old chap, be calm!"
The old chap reached his horny right
And clutched the clerky palm.

"The lines are down, out there, and, boss,
Your Jake's a man of sense—
It's *sharp* and *pointed* only 'cos
It came a thousand miles, old hoss,
Along a barbed-wire fence."

Brisbane. F. K.

Private Telephone Lines.—"Telefon" writes:—"Is it legal for a private firm to construct and maintain a private telephone line and instruments on rental, *i.e.*, can 'A' let to 'B' a line and instruments for an annual payment for a term of years? Is a license required from G.P.O.?"

[Anyone is at liberty to construct and rent a telegraph or telephone line without a license, but the rentee can only use the same for his own private purposes. Whatever liability there may be rests with the rentee, and not with the constructor of the line.—EDS. ELEC. REV.]

Ferry Works, Thames Ditton.—The following letter arrived too late for insertion in the columns devoted to correspondence:—"Permit us to thank you for your appreciative and generally accurate, though necessarily brief, notice of the life and work of our late chairman, Mr. P. W. Willans, whose death is a loss, which cannot be over-stated, to the scientific world, and to all who had the happiness to know him. But in saying that the Ferry Works were laid out and planned by Mr. Willans himself, you unwittingly do an injustice to the living. The reconstruction of the works, after they were burned down in 1888, was almost entirely the work of Mr. James Courthope Peache, who was then works manager, and who became afterwards also a member of the board of management. The selection and arrangement of tools, the system of tramways and overhead travellers, and the design of the buildings, were alike due to Mr. Peache, and when last year he resigned his positions upon the board and in the works, a piece of plate was presented to him by the company in special recognition of his services in these respects. Mr. Willans himself was so careful to disclaim credit for the admirable planning of the works, and so frequently and so cordially spoke of what Mr. Peache had done, that we feel bound, as in a sense the executors of his wishes, to ask you to insert this correction.—WILLANS & ROBINSON, LIMITED, C. S. ESSEX, *Secretary*."

An Improved Electric Bell.—It has been urged that one of the most annoying incidents arising in the use of electric bells is due to the deposition of dust at the contact points of the automatic circuit breaker which controls the vibrating mechanism. We are inclined to think that this statement is a very great exaggeration, but presuming that the defect is a real one, the arrangement devised by Mr. R. Varley, jun., and described in the *Electrical Age*, seems a good one. The contact spring attached to the armature is flattened and slightly concaved or dished at the point where the fixed contact strikes it upon retreat of the armature. A short piece of very thin rubber tubing is slipped over the flattened spring and the fixed contact is provided with a head which is forced through a small hole in the rubber. This construction permits the necessary vibration to maintain the bell in operation, and the rubber hugs the spring strip so closely at all points around the dished portion that it effectually prevents the entrance of dust. The rubber is treated to a substantial coating of paraffine, which prevents deterioration under atmospheric exposure.

London Electric Lighting Companies.—A question as to whether the electric lighting companies of London should be compelled to carry their lines through existing subways has been under the consideration of a Committee of the House of Lords, presided over by the Marquis of Bath. It was pointed out in evidence, on behalf of the companies, by the Earl of Crawford and Sir F. Bramwell that this would involve the breaking up of the streets and the divergence of established electric mains. Wires of this class involved considerations different from those of gas and water pipes, and should not be placed in charge of the same persons. The Committee, taking this view decided that the six electric lighting companies had proved their case to be exempted from the Subways Bill, and that the clause which required them to lay electric wires in subways would be rejected. Regulations, so far as electric lighting was concerned would be in the hands of the Board of Trade. A clause in accordance with the decision of the Committee was brought up last week and agreed to.

Deep Sea Soundings.—A list of 300 oceanic depths taken by ships of the Royal Navy, and 1,336 taken by those of various submarine telegraph companies during the year 1891, has recently been published by the Hydrographic Office of the Admiralty. Of these latter soundings the Eastern Telegraph Company's ss. *Chiltern* has taken 229, the *Sherard Osborn* 63, the *Great Northern* 22, the *Recorder* 44, the *John Pender* 38, and the *Electra* 34. The Société Générale des Téléphones took 362 with the ss. *Westmeath*; the Telegraph Construction and Maintenance Company took 22, and the India-Rubber, Gutta-Percha and Telegraph Works Company no less than 607 soundings. It is instructive to notice the great differences there appears to be with different ships in the number of times the sounding wire breaks. With Her Majesty's ships, out of 300 soundings, the wire is stated to have broken 11 times, or an average of 3·7 per cent. With the Société Générale des Téléphones, during 362 soundings, the wire broke twice, an average of 0·55 per cent.; while with the Telegraph Construction and Maintenance Company it broke twice during 22 soundings, or an average of 9 per cent., and with the India-Rubber, Gutta-Percha and Telegraph Works Company, during 607 soundings, it broke 33 times, or an average of 5½ per cent. Making every allowance for differences in weather experienced, and the depths of the soundings, the range of 0·55 per cent. to 9 per cent. still seems a remarkable one.

Electric Light Accident in America.—A Reuter's telegram from New York states that an extraordinary accident occurred on 28th inst. at the Edgar Thomson Steel Works at Braddock, Pennsylvania. A number of men were working on a travelling crane in the blacksmith's shop, when the boom came in contact with an electric light wire, and cut through the insulation. Instantly the force of the current passed down the iron framework of the crane. All the men at once fell to the ground insensible, and two of them were killed. Probably this will be credited by some of our "leading lights" to the vivid imagination of the trans-Atlantic pressmen.

Church Electric Lighting.—The electric light is about to be introduced into the St. Austell parish church.

Aluminium in Austria.—The erection of a factory is contemplated at Obermühle in Upper Austria, where the manufacture of aluminium will be carried on. Water power will be employed to drive the neccessary machinery.

Correction.—In the translation of "Tension Reducing Transformers" in last week's article, page 667, we have it: "circuits between the two long or short induction coils." It should read "short or long circuits between the two induction coils."

Cambridge Electric Lighting Order.—It is announced in the London *Gazette* that it is intended to transfer the powers, duties, liabilities and works under the 1890 order, to the Cambridge Electric Supply Company, Limited. The consideration to be paid by the company to the corporation is the sum of £2,040.

Electricity Supply Corporation. — The *Financial Observer* criticises very strongly the prospectus of the Electricity Supply Corporation, in which the new capital is offered for subscription. Amongst other lengthy remarks we notice the following:—"On the whole, although this scheme cannot be put down in the wild cat category, we scarcely think it is a safe investment, and under the circumstances, we think our readers will do well not to purchase its shares, or if they have already written in for any, to cancel their applications."

A Flat Carbon Arc Lamp.—The object of this invention (which is due to Mr. R. E. Ball, of New York) is to obtain an increased length of time of burning than can be obtained with the ordinary round carbon. In this lamp the lower carbon is of the ordinary description, but the upper one is several times broader than it is thick. The motion of this carbon is a side to side as well as a falling one. It does not appear that the idea, which seems to be a hopeful one, has been fully worked out in all the necessary practical details.

Gramme Winding of Multipolar Dynamos.—Mr. Ernest Scott writing to *Industries* refers to a description, which appeared in that contemporary recently, of a multipolar dynamo constructed by the Edison General Electric Company, in which it is stated that there is some objection to Gramme winding for this type of machine. Our contemporary replies to Mr. Scott as follows:—"The objection to Gramme winding for multipolar machines is that if the armature be the least out of centre, or if some of the fields be of a better quality of iron than others, the armature is not evenly loaded, at light loads it is partially short-circuited on itself, and at full load the current density is greater on one side than the other.

The Engineering Exchange.—The ceremonial opening of the Engineering Exchange, 22, Billiter Street, took place at noon on Tuesday last. Under the presidency of the founder, Mr. Reginald Bolton, the committee were appointed, the objects of the promoters explained, and the exchange formally inaugurated. In the evening a commemorative dinner was given in the London Tavern, when Sir Albert K. Rollit, M.P., LL.D., Chairman of the London Chamber of Commerce, took the chair. The object of the exchange is to afford a central address and place of daily meeting for all parties interested in engineering business, and a rendezvous for country members and foreigners visiting London on engineering matters. The exchange comprises reading room, general and private writing rooms, exchange rooms, telephones, and an information bureau. High change is to be held every Tuesday from 12 to 1, when it is expected that all members will be in attendance. An influential committee has been formed, including representatives, as far as possible, of all branches of the engineering profession, and the inauguration was so far successful as to be indicative of a useful and prosperous career. The Jerusalem Shipping Exchange, hitherto located at Cowper's Court, Cornhill, has removed to the same address as the Engineering Exchange, and it has been arranged that the two institutions, though not actually amalgamated, shall co-operate for mutual benefit.

Electric Locomotives: a Correction.—Professor Silvanus P. Thompson writes:—"A passage in the newly published fourth edition of my "Dynamo-Electric Machinery" requires correction, being technically inaccurate. On p. 616 the statement occurs that the electric locomotives of the South London Electric Railway are now being replaced by some of Messrs. Siemens's locomotives. In justice to Messrs. Mather & Platt it ought to be stated that the fourteen original locomotives supplied by them are still running, and that they have run in the aggregate no less than 450,000 miles. The two more recent locomotives supplied by Messrs. Siemens do not replace but are supplementary to the original engines."

Sheffield Telephone Service.—A meeting of telephone subscribers to receive the report of the committee appointed at the previous meeting, and to consider the desirability of forming a permanent association to protect the interests of the Sheffield subscribers, was held on Monday last at Sheffield. The report stated that the National Company had consented to modify their original proposals in favour of all existing long distance subscribers, and proposed the following tariff:—

	Per annum.
1½ miles from the Parish Church, or any of the sub-exchanges in the Sheffield free radius, as defined in the circular of 20th April	£8 0 0
2 miles from do. do.	£10 0 0
and £2 10s. per ½ mile extra for distances exceeding 2 miles, but for existing subscribers, per ½ mile beyond 2 miles	£1 5 0
Private residences within a radius of 2½ miles from any of the above centres	£7 0 0
and an additional £2 10s. per ½ mile beyond, but to existing subscribers, per ½ mile beyond	£1 5 0

There was a great deal of discussion, and Mr. Gaine, of the National Telephone Company, addressed the meeting, after which the following resolution was adopted: "That in the opinion of this meeting it is desirable that an association of Sheffield telephone subscribers be formed, and that the first members shall be those who have contributed a subscription of 5s. in response to the circular of May 18th." It was afterwards also resolved that the committee of subscribers appointed at the meeting held on May 9th, should be the executive committee of the subscribers' association (with power to add to their number) to act for the subscribers and to take any steps they thought needful in their interests.

NEW COMPANIES REGISTERED.

Electrical Installation Company, Limited.—Capital, £1,800 in £1 shares. Objects: To carry on business as electrical, mechanical, and hydraulic engineers; to generate, accumulate, distribute and supply electricity, and to act as agents for the sale of electrical machinery and appliances. Signatories (with one share each), Mr. and Mrs. J. G. O'Brien, 2, Egerton Mansions, South Kensington; E. L. O'Brien, 6, South Street, Thurlow Square, S.W.; Mrs. T. O'Brien, 6, South Street, Thurlow Square, S.W.; C. E. Heath, Lloyds, E.C.; Captain H. A. N. Fyers, 19, Onslow Gardens, S.W., and E. W. H. Fyers, of 96, Eaton Terrace (electrical engineer) with 599 shares. The number of directors is not to be less than two nor more than seven, the first being J. G. O'Brien, E. L. O'Brien, and E. W. H. Fyers. Qualification, £200. Remuneration of above directors, who are also managers, £50 per annum and a percentage of the profits. Registered on the 27th ult, by J. C. Wheeler, 6, New Inn, Strand, W.C.

Veale & Company, Limited.—Capital, £10,000 in £1 shares. Objects: To enter into an agreement with J. E. Veale, of St. Austell, Cornwall, for the acquisition of the business, machinery, stock, &c., of J. E. Veale, and for the purchase by and transfer to the company of the Board of Trade license to supply electricity in the local board district of St. Austell, and to carry on the business of electricians, mechanical and electrical engineers, suppliers of electricity, and manufacturers of electrical apparatus. Signatories: J. E. Veale, St. Austell (200 shares); A. Coode, St. Austell

(50); T. R. Bolitho, Penzance (50); W. J. Lovering, St. Austell (50); J. F. Albright, Mansion House Buildings, E.C. (1); C. F. Tufnell, Lloyd's, E.C. (1); R. E. Crompton, Mansion House Buildings, E.C. (1). The number of directors is not to be less than two nor more than five, the first to be nominated by the subscribers. Registered on the 26th ult. by Crompton & Co., Mansion House Buildings, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Abell's Electrical Engineering Company, Limited.—An agreement made the 7th ult. between Messrs. T. K. Abell and T. Hughes (called the vendors) of the one part, and the company of the other part, states that the vendors shall sell, and the company purchase, the business of electrical engineers carried on under the style of "Abell and Hughes," at the steam factory, Raglan Street, St. Helen's, Lancashire, and that the consideration therefor should be £650, to be satisfied by the payment of £50 in cash, and the allotment of 65 fully paid £5 shares to T. K. Abell, and by the allotment of 55 fully paid £5 shares to W. Hughes.

Brazilian Submarine Telegraph Company, Limited. The annual return of this company, made up to the 18th ult., was filed on the 24th ult. The nominal capital of the company is £1,300,000, in £10 shares. All the shares have been taken up, the full amount called, and all calls paid.

Electricity Supply Corporation, Limited.—An agreement made the 19th May, 1892 (filed on the following day), made between the above-named corporation of the one part, and Messrs. A. and S. Gatti of the other part, states that whereas the corporation is indebted to Messrs. A. and S. Gatti for a very large amount, and whereas by a former agreement dated the 18th May, 1892, it was agreed that Messrs. Gatti should be allotted such a number of shares as, including the shares taken up, should amount to £50,000; and since at the time of the agreement £3,590 in shares had been taken up, the present agreement determines that the corporation shall allot 9,282 fully paid shares of £5 each to Messrs. Gatti, the shares to be numbered 719 to 10,000 inclusive. Registered office, 12, Maiden Lane, Covent Garden, W.C.

Edison Gower-Bell Telephone Company, of Europe, Limited.—The annual return of this company, made up to the 14th April, was filed on the 19th April, 1892. The nominal capital of the company is £500,000 in £1 shares. Of these 385,009 have been taken up, of which 370,000 have been issued as fully paid. Upon the remainder the full amount has been called, the calls paid amounting to £15,005, and leaving £4 unpaid. Registered office, 53, New Broad Street, E.C.

Mather and Platt, Limited.—An agreement, made the 14th ult. (filed on the 18th ult.), between William Mather and John Platt (called the vendors) of the one part, and the company of the other part, determines that the vendors shall sell their business of engineers carried on at the Salford Ironworks, Manchester, and that the purchase consideration shall be £272,155 17s. 4d. This sum is to be satisfied as follows:—£100,000 in 1,000 debentures of £100 each, bearing interest at 5 per cent., and redeemable in 1902 at 105 per cent.; £135,000 by the allotment of 15,000 shares of £10 each, on each of which the sum of £9 is to be credited as paid up, and the balance (£37,155 17s. 4d.) in cash. The purchase is to be considered as from January 1st, 1892, and was to be completed on June 1st, 1892. Registered office, Salford Ironworks, Salford, Lancashire.

Manlove, Alliott and Company, Limited.—The annual return of this company, made up to April 9th, was filed on the 23rd following. The nominal capital is £100,000 in £10 shares; 4,599 shares have been taken up, of which 4,546 have been issued as fully paid. Upon the remaining 53 shares the full amount has been called and paid; 664 of the fully paid shares have been forfeited during the past year. Registered office, Bloomsgrove Works, Radford, Nottingham.

London Platino-Brazilian Telegraph Company, Limited.—The annual return of this company, made up to the 16th ult., was filed on the 20th ult. The nominal capital is £400,000 in £10 shares. Of these, 37,548 shares have been taken up, all of which have had the full amount called and paid. Of the shares issued, the Western and Brazilian Telegraph Company, Limited, holds 36,635. Registered office, 19, Great Winchester Street, London, E.C.

Elieson Electric Company, Limited.—This company was dissolved under Clause 7 (4) of the Companies Act (43 Vict., ch. 19), by notice in the London *Gazette*, dated May 10th, 1892. The capital of the company was £600,000 in £5 shares, and its objects were to take over the business of the Electric Locomotive and Power Company, Limited, and to manufacture and deal in electric locomotives, electric tram engines, dynamos, electric storage batteries, torpedo boats, &c.

W. T. Henley's Electric Light and Power Company, Limited.—The following notice was filed on May 19th, 1892:—At an extraordinary general meeting of the members of this company, duly convened and held at 27, St. Martin's Lane, E.C., on March 22nd, 1892, the following special resolutions were duly passed, and at a subsequent extraordinary general meeting of the members of the said company, duly convened and held at the same place on April 7th, 1892, the following special resolutions were duly confirmed:—(1) That the company be wound up voluntarily, and that Mr. John B. Ball, chartered accountant, of No. 1, Gresham Buildings, Basinghall Street, in the City of London, be, and is hereby, appointed liquidator to conduct the winding up, at a remuneration of £25, with power to distribute the shares in W. T. Henley's Telegraph Works Company, Limited, to those shareholders who are willing to accept the same, at the rate of one share in W. T. Henley's Telegraph Works Company, Limited, for 10 shares in W. T. Henley's Electric Light and Power Company, Limited, and to realise a like proportion of the shares of W. T. Henley's Telegraph Works Company, Limited, and distribute the proceeds among those who do not assent to such arrangement, or who are holders of less than 10 shares, and with further power to realise any remaining shares, and then to divide proportionably among the whole of the shareholders any cash remaining in his hands after payment of all liabilities. (2) That the sum of £100 be voted to the directors for their past services, to be divided in such manner as they may agree, and that the sum of £25 be voted for the services of the secretary."

Anglo-General Electric Light Company, Limited.—The following notice has been received from the liquidator of this company, and was filed on the 20th inst. "To the Registrar of Joint Stock Companies. I beg to inform you that a meeting of the above-named company was duly held on May 10th, 1892, for the purpose of having an account laid before them showing the manner in which the winding up had been conducted, and the property of the company disposed of, and that the same was done accordingly. (Signed) C. F. Reynold, liquidator.

Oriental Telephone Company, Limited.—The annual return of this company, made up to the 11th inst., was filed on the 16th inst. The nominal capital is £300,000, divided into 225,000 ordinary and 75,000 founders' shares of £1 each. Of these, 223,494 ordinary and all the vendor's shares have been taken up, of which 3,494 ordinary and the 75,000 vendor's shares have been issued as fully paid. Upon the remaining 220,000 ordinary shares a call of 11s. has been paid on each share. At extraordinary general meetings of the company, held on the 27th ult. and the 12th inst., the following special resolution was respectively passed and confirmed: "That the name of the company be changed to the Oriental Telephone and Electric Light Company, Limited." Registered office, 14, Austin Friars, E.C.

Electric "Sun" Lamp and Power Company, Limited.—The following notice was filed on May 20th, 1892: "We have to inform you that a meeting of the Electric 'Sun' Lamp and Power Company, Limited, was duly held, pursuant to Section 142 of the Companies' Act, 1862, on May 6th, 1892, for the purpose of having an account laid before them, showing the manner in which the winding up of the company had been conducted, and the property of the company disposed of, and that the same was done accordingly. (Signed) M. J. F. Brickdale, Wm. Perkins, Henry de Grelle, liquidators."

Galloways, Limited (boiler makers and mechanical and electrical engineers).—The annual return of this company, made up to March 2nd, was filed on March 4th. The nominal capital is £250,000, in £100 shares. 2,108 shares have been taken up, the full amount called, and all calls paid. Registered office, Knott Mill Iron Works, Manchester.

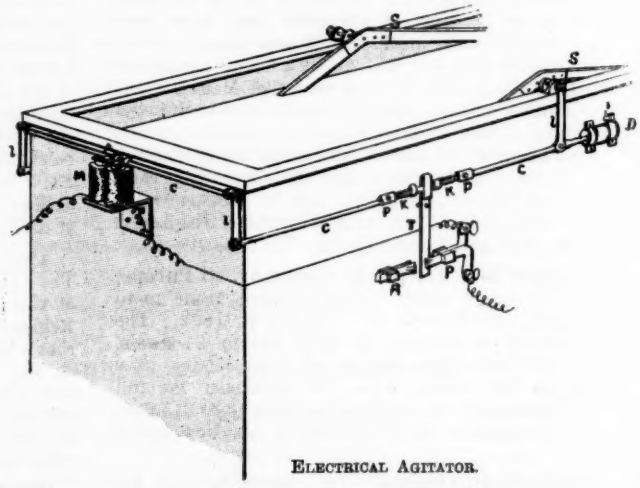
BUSINESS NOTICES, &c.

Catalogues.—Messrs. Charles Churchill and Company, Limited, have lately got out a new catalogue, illustrating the American machine tools which they are placing before the trade in this country. This book is a spendid specimen of a machinery catalogue, almost every tool mentioned being fully illustrated and particularised as regards its working, and prices of same are also minutely gone into. The tools described are for the use of those connected with all branches of the engineering and the iron and steel trades. The firm supply all classes of apparatus, from a 56 inch planing machine, to a small cast steel file. They have a large stock of the goods at their London and Birmingham warehouses. We have much pleasure in recommending this catalogue to the engineering trades.

Ship Lighting.—The new steamer *Iona*, in course of construction in the shipbuilding yard of Messrs. Gourlay Bros. and Co., Dundee, is to be lighted throughout with the electric light. The contract is in the hands of Messrs. Lowdon Bros., electrical engineers, Dundee. The same firm have recently completed the electric light installation on board the new steamer *London*, built by Messrs. Gourlay Bros. and Co. for the Dundee, Perth, and London Shipping Company.

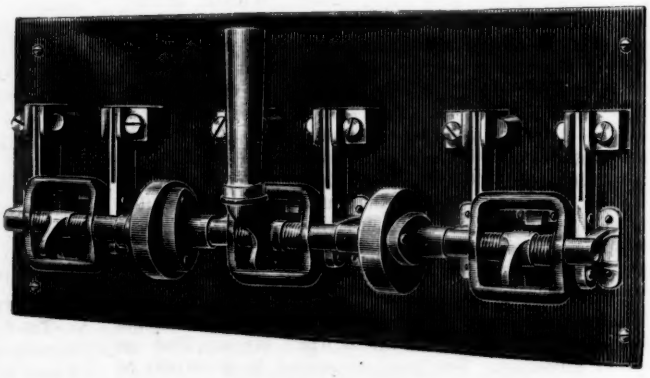
Hotel Electric Lighting.—The Great Northern Railway Company, who have recently purchased the Victoria Hotel, Bradford, have entrusted the contract for the bell work and electric lighting of the hotel to the Bradford branch of Messrs. Woodhouse & Rawson, United, Ltd. The current required is to be obtained from the Bradford Corporation central station.

Electrical Stirrer, or Agitator. — The principle of the electrical stirrer, illustrated, is as follows:—An armature, A, is actuated by an electro-magnet, M, the motion of which is communicated to the stirrer, S S, by cranks, *p p*, and connecting rods, C C. The stirrer is so weighted, that when at rest one arm, viz., the one farthest from the magnet, makes an angle of about 15° with the perpendicular, and the armature, A, is about $\frac{3}{8}$ths of an inch above the poles of the magnet. The current being switched on, the armature, A, is pulled down, and the stirrer, S, is moved about its centre, lifting the weighted arm and sinking the other. In doing this the stops, *p p*, on the connecting rod, *c*, bring pressure through springs, *k k*, to bear on the switch, which breaks contact at P, and remains held by the stop, R. The circuit being broken, the weighted arm of the stirrer, S, gradually sinks until the pressure of the spring, K, is sufficient to overcome the friction which holds the switch, T, in the stop, R, when contact is again made at P. The stops, *p p*, are adjustable on the connecting rod, C, so that the time of make and break may be easily adjusted. To steady the motion and vary the number of strokes per minute, a dashpot, D, with an adjustable tap, *t*, is used, so that the stirrer is quickly raised, and falls slowly, dependent on the size of opening of the tap, *t*. The apparatus is manufactured by the London Metallurgical Company, Limited, of 80, Turnmill Street.



ELECTRICAL AGITATOR.

D. and S. Triple-pole Main Switch.—To meet the demand of those supply companies who wish to break three-wire circuits simultaneously, Messrs. Dorman and Smith have lately produced a triple-pole form of their well-known B type main switch. The arrangement, which is shown clearly in the woodcut, consists of three sudden release double break main switches, arranged side by side, and actuated by one handle through an insulated shaft, the coupling and insulating devices being exceedingly substantial. In Paris and Manchester, where the five-wire system of distribution obtains, five of these switches can be used instead of three.



TRIPLE-POLE MAIN SWITCH.

Trade List.—We have received from Messrs. Harold & and Jenkins a copy of their list of materials used in the construction of dynamos, transformers, and other electrical machines, as well as charcoal iron stampings. Some information and illustrations are given of wrought-iron forgings for field magnets, and best charcoal iron strips. The list should be useful to those interested.

A New Electric Tramcar.—A new tramcar, built by Messrs. Brown, Marshalls & Co., Limited, Birmingham, for the Bristol Road electrical tramway route—to run from Navigation Street to Bournbrook—is being inspected by the Board of Trade, and was to be put on for service this week. The electric fittings have been added by the Electric Construction Corporation, Limited, of Wolverhampton.

Electric Lighting of Wetley Abbey, Stoke-on-Trent.—The Manchester branch of the Brush Electrical Engineering Company have just completed an installation at the residence of J. Hardman, Esq., which is noteworthy, in that it demonstrates the success with which electric lighting can be carried out in a country mansion with a petroleum engine as the prime motor. The installation consists of 60 16-C.P. lamps, with a battery of accumulators. A 7 brake H.P. Priestman oil engine is used to drive a Victoria dynamo, which, in turn, supplies current to the cells. The switchboard is arranged that the lamps can be fed (*a*) direct from the storage battery; (*b*) from the dynamo and battery in conjunction; (*c*) from the dynamo direct. The working of the whole plant is very satisfactory.

Weymersch Electric Battery Syndicate.—The temporary lighting of Vintners' Hall, on Thursday last week, on the occasion of a ball, was carried out by the Weymersch Electric Battery Syndicate, and gave the greatest satisfaction. In the ball-room were placed four wrought-iron brackets holding five 16 C.P. lamps each. In the refreshment room four lamps were placed with shell reflectors, lighting two large banks of flowers in the windows. Altogether 24 lamps were supplied from this company's batteries. The light was steady and constant throughout the evening.

Woodhouse and Rawson.—Messrs. Woodhouse and Rawson United, Limited, have now opened a fully-constituted branch of their business for the Midlands at "Minories, Birmingham," and have taken over the show rooms there recently occupied by the Midland Electricity Company, together with the supply trade of that firm, who will in future devote themselves exclusively to the engineering and constructing department. This change has already proved of considerable advantage to the local contractors and other buyers of electrical material, as the stock is very complete.

New Branch.—We are informed by Messrs. Woodhouse and Rawson United, Limited, that they have opened a branch office and show room at 22, Rue Lafitte, Paris, which will be the chief depôt for their French trade, and all communications regarding same should be addressed to Mr. E. Kenealy, the manager there, who will give same his prompt and careful attention. Mr. E. H. Cadiot no longer represents the firm in France.

The Electric Light at Southampton Public Baths.—The baths and wash-houses committee of the Southampton Town Council received thirty-six tenders for the electric lighting of the public baths, and the council have endorsed the recommendation to accept the tender of the Newton Electrical Engineering Works, Taunton, to carry out the work for £324, subject to the sureties being satisfactory, and also to the approval of the Local Government Board.

Manchester Electric Lighting.—The Gas Committee of the Manchester Corporation are prepared to receive applications for the position of clerk of works, to superintend the construction and erection of dynamos, engines, boilers, and other apparatus, and the laying of the mains and conductors, in connection with the electric installation. Applications must be forwarded to Mr. C. Nickson, Superintendent, Gas Department, Town Hall, Manchester, on or before June 24th, 1892, addressed Chairman of the Gas Committee, Manchester, and endorsed "Clerk of Works." See our advertisements for further particulars.

Electric Communication with Lighthouses.—The Telegraph Construction and Maintenance Company have been entrusted with the work of connecting the Needles Lighthouse with the postal telegraph system, and it is being carried out under the superintendence of Captain Halpin, the company's superintendent.

The Exchange Telegraph Company.—This company have given public notice that they are the proprietors of certain patents for column printing telegraph instruments, and will take legal proceedings against all persons using or selling instruments which are infringements of the same.

Tenders Accepted—Glasgow.—The following is a list of the tenders sent in for the central station at Glasgow:—

Boilers	Lindsay, Burnett & Co., £4,700.
Engines, dynamos, and steam connections ...	Latimer Clark, Muirhead & Co., £12,918.
Secondary batteries ...	Crompton-Howell Company.
Cable	Henley's Telegraph Company and the India-Rubber Company.
Troughs, service boxes, &c.	R. McLaren & Co.
Laying the above „ ...	Wm. Pollock.
Insulators	Jas. Stiff and Sons.
Copper strip	Elliott's Metal Company.

Tender Accepted—Huddersfield.—The tender of the Bradford branch of Messrs. Woodhouse & Rawson United, Limited, for wiring and fitting the borough surveyor's office at Huddersfield has been accepted.

Tenders Wanted—Telegraph Stores.—The directors of the North-Eastern Railway are prepared to receive tenders for the under-mentioned articles, in such quantities as they may require, during the six months ending December 31st, 1892, delivered carriage paid at the company's telegraph stores at York:—1. Telegraph apparatus. 2. Telegraph wire and line stores. Forms of tender may be obtained on application to Mr. Graves, Telegraph Department, York, and tenders must be sent in to Mr. C. N. Wilkinson, the Secretary, at York, sealed and marked, "Tender for Telegraph Stores," not later than noon on Tuesday, June 7th.

Tenders Wanted—Bishop's Stortford.—Tenders are invited for lighting the public streets, at present lighted, of the district of Bishop's Stortford for one year from August 16th, for the Local Board. Tenders must be on forms which will be supplied by the Board, and must be delivered to Mr. W. Gee, clerk, North Street, Bishop's Stortford, by 10 a.m. on 18th inst. Possibly there is a chance for electric contractors to quote!

Tenders Wanted—Bristol.—The Bristol Urban Sanitary Authority are inviting tenders for the supply, &c., of condensers, pumps, and steam and other pipes at the central electric lighting station, Temple Back, Bristol. Particulars regarding forms of tendering, latest date, &c., will be found in our advertisements.

Tenders Wanted—France.—Tenders are being invited until June 9th by the Minister of Commerce and Industry at the General Direction of the Posts and Telegraphs, Paris, for about 80 tons of copper wire.

Tenders Wanted—Spain.—Tenders are being invited until June 29th by the civil authorities of Zamora, Spain, for the electric lighting of the town.

CITY NOTES.

Reuter's Telegram Company (Limited).

THE Directors' report, presented at the twenty-eighth ordinary general meeting of the shareholders, held at the Company's offices, 24, Old Jewry, on Wednesday last, states that the net profits for the year ending December 31st last, after payment of current expenses, and deducting rebate on unexpired subscriptions, amount to £1,514 6s. 10d., including the amount brought forward from the last account. In accordance with the articles of association, the directors have charged extraordinary expenditure for alteration of premises, &c., to the reserve fund, and have transferred £3,000 to profit and loss account. From the amount thereby made available for distribution the directors declare a dividend of 5 per cent. free of income-tax, for the year 1891. This will absorb £4,415 9s. 6d., and leave a balance of £98 17s. 4d. to be carried forward. The dividend warrants will be payable on the 4th prox. In conformity with the articles of association, Baron George de Reuter retires from the direction, but offers himself for re-election. Messrs. Welton, Jones & Co. offer themselves for re-election as auditors.

The SECRETARY having read the notice convening the meeting,

The CHAIRMAN (Admiral Sir J. C. D. Hay, Bart., K.C.B.) said: I have now to move the adoption of the report. Before, however, making a few remarks on the operations of the company during the past year, I think a few words of explanation are due to shareholders in reference to the delay which has occurred in holding the annual meeting. June 1st is the regular date fixed by the articles of association, but in former years it has been found possible to complete the accounts by the end of April. This year, however, owing to the greater scope of our business, and the more complicated accounts we have to deal with, we have been obliged to revert to the original practice of holding the annual meeting at this period, and it may be a good opportunity to state, that in all probability, we shall not be able to submit the accounts at an earlier date in future. Turning to the profit and loss account, you will find that the revenue from the telegraphic business shows no retrogression. On the other hand, there has been a large increase of expenditure for telegrams and agencies. This increase occurred chiefly during the first half of 1891, when events of exceptional importance were happening in distant quarters of the Globe, chiefly North and South America. The second half of the year has shown a very material improvement, which has been maintained up to the present time. In the opinion of the directors, the results for the past year are satisfactory, taking into account all the exceptional circumstances with which the company has had to contend. Without venturing to prophecy, we have good reason to hope that we shall this year earn a fair dividend and be able to strengthen the reserve fund, which I may remark, for the information of new shareholders, was primarily built up to equalise the dividend. The extraordinary, and I may add, not recurring expenditure, referred to in the report, comprises chiefly alterations to the premises, 24, Old Jewry, necessitated by the increased staff we have to employ, and also by the telephone service between London and Paris. This service has involved important structural re-arrangements, chiefly in order to secure a room impervious to outside sounds, as only the most expert telephonists are able to catch the sound of the voice coming over such a long distance. The lease of 25, Old Jewry has been acquired for our advertisement business, which may be said to be still in its infancy. The legal formalities which had to be gone through before we could commence operations were only completed about the middle of last year, and, since then, as you are aware, there has been considerable financial depression, which reacts immediately on advertising. We have not taken credit in the profit and loss account for any profit made under this head last year, but have applied it in reduction of the preliminary outlay incurred for the organisation of the new branch. We have every confidence that with a revival of financial and commercial activity advertising will prove a lucrative source of income to the company. With these few remarks I beg to move the adoption of the report.

This was seconded by Baron GEO. DE REUTER, and carried unanimously.

The Hon. MARK F. NAPIER moved, and the CHAIRMAN seconded, the re-election of Baron Geo. De Reuter as director of the company. This was agreed to.

Messrs. Welton, Jones & Co. were re-elected auditors to the company for the ensuing year at a remuneration of 25 guineas.

A vote of thanks to the chairman and the officers of the company closed the meeting.

The Cambridge Electric Supply Company, Limited.—

The prospectus of this company, which has just been issued, states the authorised capital to be £50,000, in shares of £10 each. The directors are Sir B. C. Brown, D.C.L., Gerard B. Finch, M.A., David Munsey, Hon. C. A. Parsons, J. B. Simpson, Geo. Whitmore. The managing director is Hon. C. A. Parsons. The company has been formed for the purpose of supplying the electric current for lighting, heating, and motive purposes in the town and University of Cambridge. It is estimated that an expenditure of £25,000 will be required to enable the company to commence operations on a proper scale, and it is expected that the light will be turned on by the beginning of October next. A canvass which has been made satisfies the directors that they will commence their operations with a good prospect of success. The company will be worked on the same lines as the Newcastle and District Electric Lighting Company. The price to be charged for current for private consumers will be 7d., and for street lighting 5½d. per Board of Trade unit. No contracts have been entered into by the company excepting for a building site. The list of applications closes on June 13th. Registered offices, 2, Sidney Street, Cambridge.

Brazilian Submarine Telegraph Company, Limited.—The directors of this company, on Wednesday last, declared an interim dividend of 3s. per share, free of income tax, for the quarter ended March 31st last, and payable on the 24th inst. The transfer books of this company will be closed from the 17th to the 23rd inst., both days inclusive.

Islington and General Electric Supply, Limited.—The list of applications in this company closed on Tuesday last. The shares were dealt in at ¼ to ⅜ premium.

TRAFFIC RECEIPTS.

The Eastern Telegraph Company, Limited. The traffic receipts for the month of May, 1892, were £54,842, and £53,829 in the corresponding period of 1891.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending May 27th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company Limited, amounted to £2,449.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation, May 26th.	Closing Quotation, June 2nd.	Business done during week ending June 2nd, 1892. Highest.	Lowest.
250,000*l*	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	100 —103	101 —104	...	...
1,300,980*l*	Anglo-American Telegraph, Limited	Stock	48 — 49	48 — 49	49	...
2,849,510*l*	Do. do. 6 p. c. Preferred	Stock	88 — 89	88½ — 89½	89¼	88½
2,849,510*l*	Do. do. Deferred	Stock	11¼ — 11⅜	11 — 11½	11 7/16	11¼
130,000	Brazilian Submarine Telegraph, Limited	10	10½ — 11	10¼ — 10⅝	10⅝	10 7/16
53,200*l*	Do. do. 5 p. c. Bonds	100	101 —104	101 —104	...	...
75,000*l*	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	104 —108	105 —109	...	...
77,978	Brush Electrical Engineering Ordinary, Nos. 1 to 63,416	3	3 — 3½	2⅞ — 3⅛	3⅛	3
69,996	Do. do. Non cum. 6 p. c. Preference, Nos. 1 to 63,416	2	2 — 2¼	2 — 2¼	2¼	...
40,000	Chili Telephone, Limited, Nos. 1 to 40,000	5	3½ — 4½	3½ — 4½	...	...
50,000	City and South London Railway, Nos. 1 to 50,000	10	2⅝ — 3⅛	2⅝ — 3⅛	...	...
30,152	City of London Elec. Lighting Co., Ltd., Ord. 40,001-70,152, £4 paid	10	7¼ — 8¼	9⅛ — 10¼	8 1/16	7⅞
$7,716,000	Commercial Cable, Capital Stock	$100	158 —163	158 —163	160½	...
224,850	Consolidated Telephone Construction and Maintenance, Limited ..	14/-	1/- — 3/8	1/- — 3/8	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Cum. Pref. Shares, Nos. 1 to 20,000	5	5¼ — 5⅜	5¼ — 5⅜	5 1/16	...
16,000	Cuba Telegraph, Limited	10	11 — 12	11 — 12	...	...
6,000	Do. do. 10 p. c. Preference	10	16½ — 17½	16½ — 17½	...	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	3¼ — 3⅜	3¼ — 3⅜	3⅜	...
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10	...	...
60,710	Direct United States Cable, Limited, 1877	20	11½ — 11⅝	11½ — 11⅝	11 13/16	11 3/4
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14⅜ — 15	14⅜ — 15	14⅝	14¼
70,000	Do. 6 p. c. Preference	10	15¼ — 15⅜	15¼ — 15⅜	15 1/16	15⅛
200,000*l*	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	105 —109	107 —110	...	...
1,200,000*l*	Do. 4 p. c. Mortgage Debenture Stock	Stock	108 —111	108 —111	109½	108
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	14⅞ — 15⅛	15 — 15¼	15¼	15
78,300*l*	{ Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326 }	100	103 —106	103 —106	...	...
276,200*l*	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	103 —106	103 —106	...	...
320,000*l*	Do. 4 p. c. Debenture Stock	Stock	108 —111	108 —111	109¼	109
135,000*l*	{ Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343 }	100	102 —105	102 —105	...	...
180,400*l*	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	102 —105	102 —105	...	...
201,600*l*	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	101 —104	101 —104	...	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	5⅝ — 6¼	5¼ — 6	6	5⅞
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	... ...	... ...	...	...
66,750	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	1⅛ — 1⅜	1⅜ — 1⅝	1 11/16	1½
70,000	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	2¼ — 2½	2⅜ — 2⅝	2 13/16	2⅝
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	1⅜ — 1⅝	1⅜ — 1⅝	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 10s. only paid)	5	2 — 3	2 — 3	...	...
180,227	Globe Telegraph and Trust, Limited	10	10½ — 10⅝	10½ — 10½	10 7/16	10 3/16
180,042	Do. do. 6 p. c. Preference	10	15⅜ — 15⅝	15½ — 15⅝	15⅝	15¼
150,000	Great Northern Tel. Company of Copenhagen	10	18¾ — 19¼	18¾ — 19¼	19⅛	19
220,000*l*	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	106 —109	106 —109	108¼	107½
12,134*l*	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	7⅜ — 8½	7⅜ — 8½	...	...
9,600*l*	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	9½ — 10½	9½ — 10½	...	...
41,600	India-Rubber, Gutta Percha and Telegraph Works, Limited ..	10	19½ — 20½	19½ — 20½	20¼	20
200,000*l*	Do. do. 4½ p. c., Deb., 1896	100	102 —105	102 —105	...	...
17,000	Indo-European Telegraph, Limited	25	40 — 42	40 — 42	...	...
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	3½ — 4½	3½ — 4½	...	...
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	8 — 9	8 — 9	...	...
30,000	†Liverpool Electric Supply, £3 paid	5	3 7/16 — 3 9/16	3 7/16 — 3 9/16	3½	3⅜
10,000	Do. do. fully paid	5	5 5/16 — 5 3/8	5 5/16 — 5 3/8	5⅜	4⅞
38,348	London Platino-Brazilian Telegraph, Limited	10	6 — 7	6 — 7	...	...
100,000*l*	Do. do. do. 6 p. c. Debentures	100	106 —109	106 —109	...	...
49,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	7½ — 8	7½ — 7⅝	7⅝	...
447,234	National Telephone, Limited, Nos. 1. to 438,984	5	4¼ — 4½	4⅜ — 4⅝	4 13/16	4 5/16
15,000	Do. 6 p. c. Cum., 1st Preference	10	13 — 13½	13½ — 13⅝	13 5/16	13½
15,000	Do. 6. p. c. Cum. 2nd Preference	10	12½ — 12⅝	12½ — 13	...	...
420,000*l*	Do. 4½ p.c. Deb. Stock Prov. Certs. fully paid ...	...	107 —109	108 —110	109	108½
250,000*l*	Do. (issued at 5 p.m., all paid)	...	104 —106	104 —106	...	...
6,318	Notting Hill Electric Lighting Company, Limited, £8 paid ...	10	4 — 5	4 — 5	...	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	3/16 — 5/16	3/16 — 5/16	...	...
9,000	Reuter's Limited	8	7 — 8	7 — 8	7½	...
18,680	St. James's & Pall Mall Electric Light Co., Ltd., Ord., 101—18,780	5	8½ — 9	8½ — 9	8 13/16	8 11/16
20,000	Do. do. 7 per cent. pref., Nos. 20,081 to 40,080	5	8 — 8½	8 — 8½	8 3/16	8 1/16
3,381	Submarine Cables Trust	Cert.	115 —120	115 —120	...	...
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	3¾ — 4	3½ — 3⅝	3⅝	3⅝
37,350	Telegraph Construction and Maintenance, Limited	12	42 — 44	44 — 46	45½	44
150,000*l*	Do do. do. 5 p. c. Bonds, red. 1894	100	101 —104	103 —106	...	...
58,000	United River Plate Telephone, Limited	5	1½ — 2½	1½ — 2½	1⅝	...
146,370*l*	Do. do. 5 p. c. Debenture Stock ...	Stock	85 — 95	85 — 95	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	7 — 8	7 — 8	...	...
271,400*l*	Do. do. 5 p. c. Debentures	100	99 —102	99 —102	101¼	101
30,000	West Coast of America Telegraph, Limited	10	3½ — 4½	3½ — 4½	...	...
150,000*l*	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	102 —106	102 —106	...	...
67,007	Western and Brazilian Telegraph, Limited	15	9½ — 10	9¼ — 9⅜xd	9½	9⅜
30,364	Do. do. do. 5 p. c. Cum. Preferred	7½	6 — 6½	6 — 6¼xd	6⅝	...
30,364	Do. do. do. 5 p. c. Deferred	7½	3½ — 4	3¼ — 3⅜xd	3 9/16	...
189,700*l*	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	105 —108	105 —108	...	...
237,200*l*	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	105 —108	105 —108	...	...
88,321	West India and Panama Telegraph, Limited	10	1¼ — 1½	1⅜ — 1⅝xd	1 11/16	1½
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	10 — 10½	9½ — 10xd	9 13/16	9¾
4,669	Do. do do. 6 p. c. 2nd Preference ...	10	9 — 10	8 — 9xd	...	...
80,000*l*	Do. do. 5 per cent debentures (1917) No. 1 to 1,000	100	102 —106	102 —106	...	...
$1,536,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	115 —119	115 —119	...	...
173,100*l*	Do. do. 6 p. c. Sterling Bonds	100	100 —103	100 —103	...	...
59,900	*Westminster Electric Supply Corp., Ord., Nos. 101 to 42,953 ...	5	6½ — 7	6½ — 7	...	...

* Subject to Founders' Shares. † Quotations on Liverpool Stock Exchange.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED:—Blackpool Electric Tramway Company, Limited, £10 (£6½ paid) 7⅛—7⅜.—Electric and General Investment, shares of £5 (£1 paid), 2—2½.—Founders' shares, 150—200.—Elmore Foreign and Colonial Copper, Founders' shares, 6¾—7½.—European Sims-Edison Torpedo Company, shares £20 (fully paid), 20—20½.—Founders' shares, 10—20.—Halifax and Bermuda Cable, 4¼ per cent. bonds 80—90.—House to House Company (£5 paid) 2½—3½.—7 per cent. Preference Shares of £5 (fully paid) 5¼—5⅝.—Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid), 5¾—6, 1st Preference Cumulative 6 per cent., £5 (fully paid), 5½—6.—Liverpool Electric Supply Shares of £5 (fully paid), 5 1/16—5⅜.—Manchester, Edison and Swan Company, £9 (£1 paid), ⅛—¼.—Metropolitan Electric Supply Company, Founders' shares, £0—£10.—Queen Anne's Mansions Lighting and Heating, Deferred shares of £10 (fully paid), 10—¼.—Do. 4½ per cent. preference shares of £10 (fully paid), 10—¼.—Do. Debentures, 103—¾.—Woodhouse & Rawson Ordinary of £5 £2 10s. paid), ¼—⅜.—£5 Preference (fully paid), 2½—3.—Ward's Electric Car (£10 paid), 1⅜—1⅝.

BANK RATE OF DISCOUNT.—2 per cent. (April 28th, 1892).

TRANSFORMERS.*

BY JOHN PERRY, D.Sc., F.R.S.

I. IN a transformer with many circuits, of resistances in ohms and numbers of turns, R_1, N_1, R_2, N_2, &c.; let the currents at any instant be C_1, C_2, &c., ampères, and let the independent electromotive forces, e_1, e_2, &c., volts be maintained in them; let I be the total magnetic induction which threads through all the circuits (10^8 C.G.S. units being taken as the unit of induction). The equations to the circuits are:—

$$e_1 = R_1 C_1 + N_1 \theta I, e_2 = R_2 C_2 + N_2 \theta I, \&c.,$$

using θ for $d/d t$.

Multiplying each equation by its N and dividing by its R and adding, we find, using A for the ampère turns $N_1 C_1 + N_2 C_2 +$ &c. and q for $\frac{N_1^2}{R_1} + \frac{N_2^2}{R_2} +$ &c.,

$$A + q \theta I = \Sigma (N_i/R_i) e_i \qquad (1)$$

If the law connecting A and I is known, it is possible to calculate I from (1), and then substituting for I in each of the circuit equations, each of the currents is known.

Instead of e_i being the electromotive force in a complete circuit, it may be the potential difference maintained at the terminals of a circuit and the letter V_i will then be used, the resistance between the terminals being R_i. If e_i or V_i has any value, the circuit is called a primary circuit. When no independent electromotive force is maintained in a circuit, it is called a secondary circuit.

II. *Substitution of one coil for two or more*:—It is evident from the way in which (1) is derived, that instead of a primary coil (V_1, N_1, R_1) and a secondary (N_2, R_2), if we substitute a primary (V_1, n_1, r_1) and if $n_1/r_1 = N_1/R_1$ and also if $n_1^2/r_1 = N_1^2/R_1 + N_2^2/R_2$, then the currents in all the other coils will be the same as before. We can therefore replace a primary and any group of secondaries by one primary coil.

It is also evident that if any group of secondaries (N_p, R_p), (N_t R_t), &c., be replaced by one secondary (n_2, r_2) such that $n_2^2/r_2 = N_p^2/R_p + N_t^2/R_t +$ &c., all the other currents will remain as before. It is, in fact, evident that if for groups of primaries and secondaries we substitute one primary coil of suitable potential difference at its terminals and resistance and number of turns, all the currents in the remaining coils will remain the same.

If two secondaries of numbers of turns, N_p and N_t, and internal resistances, r_p and r_t, have the same terminals, and together supply a current to an outside circuit, for them we may substitute one secondary of n turns and internal resistance r ohms with a permanent short circuit of resistance, ρ, between its terminals, if

$$n = (N_p^2/r_t + N_t^2/r_p) / (N_p r_t + N_t r_p)$$

$$r = r_p r_t (N_p^2 r_t + N_t^2 r_p) / (N_p r_t + N_t r_p)^2,$$

and

$$\rho = (N_p^2 r_t + N_t^2 r_p) / (N_p - N_t)^2.$$

Hence no good results can be expected from compound winding. If, instead of requiring a perfect similarity in all respects, we desire a substitution which is almost absolutely perfect in practical cases, we can obtain it by the use of a single coil with no short circuit outside, and therefore without the excessive waste of power which occurs when two coils of different numbers of turns are compounded. This last result is obtained by regarding A as a negligible term in (1).

Two coils in parallel to one another, used as a primary or secondary, will evidently waste energy in idle currents inside the transformer, unless they are exactly equal in their numbers of turns.

III. *If condensers are connected with any of the circuits, the most general case is this*:—Take the internal resistance of the sth coil to be r_s; let it have a condenser outside of capacity, K_s, in series with a resistance, ρ_s'', and let there be a resistance ρ_s', in parallel with ρ_s'' and the condenser. Then, in the general expression, instead of R_s, we must use

$$r_s + (\rho_s' \rho_s'' K_s \theta + \rho_s') / \{ (\rho_s' + \rho_s'') K_s \theta + 1 \}.$$

Having found C_s, we must remember that the part passing through ρ_s' is $(\rho_s'' K_s \theta + 1) C_s / \{ (\rho_s' + \rho_s'') K \theta + 1 \}$. Everywhere, when any resistance, r, is spoken of, if there be also a co-efficient of self-induction, l (or in case it is an internal resistance, r_s, that is spoken of, should there be magnetic leakage), we must use instead of r the expression $r + l \theta$. Our formulæ, in case there is magnetic leakage, in case there is self-induction, or in case there are condensers, really require that a complicated operation

$$\frac{a + b \theta + c \theta^2 + d \theta^3 + e \theta^4 + f \theta^5 + \&c.}{a' + b' \theta + c' \theta^2 + d' \theta^3 + e' \theta^4 + f' \theta^5 + \&c.}$$

should be performed upon a function of the time. Now the functions with which engineers deal are periodic functions, and the evanescent parts of the answers may be left out of consideration. As any periodic function of the time is the sum of simple harmonic functions, we have only to perform the above operations upon functions like $\sin (k t + m)$. But it is obvious that the complicated operation when performed on $\sin (k t + m)$ reduces to

$$(a - c k^2 + e k^4 - \&c.) + (b - d k^2 + f k^4 - \&c.) \theta$$
$$(a' - c' k^2 + e' k^4 - \&c.) + (b' - d' k^2 + f' k^4 - \&c.) \theta'$$

an operation which is very easy to perform.

Writing it in the form $(p + q \theta)/(\alpha + \beta \theta)$, the result of operating upon $\sin (k t + m)$ is to convert it into

$$\sqrt{\left(\frac{p^2 + q^2 k^2}{\alpha^2 + \beta^2 k^2}\right)} \sin \left(k t + m + \tan^{-1} \frac{q k}{p} - \tan^{-1} \frac{\beta k}{\alpha} \right).$$

Hence the most complicated cases are readily worked out when numerical examples are taken. Engineers are in the habit of speaking of the epoch m as a lead when it is positive, and as a lag when it is negative. The reciprocal of the periodic time is called the *frequency*, and k is $2 \pi \times$ frequency.

IV. *Law connecting A and I*:—

1. If μ, the magnetic permeability of the iron, is constant, let σ stand for $4 \pi a \mu 10^{-9}/\lambda$ where a is the area of cross section of the iron in square centimetres, and λ is the average length of the induction solenoids in centimetres. The curve which on squared paper illustrates the magnetic law is a straight line, and $I = \sigma A$.

2. If the curve is not a straight line, that is, if there is some indication of saturation, and there generally is some saturation where β the induction per square centimetre exceeds 2×10^{-5} (or 2,000 C.G.S. units), it will be found that a good approximation to actual facts is obtained by assuming that when $I = I_0 \sin x$, $A = A_0 (\sin x - b \sin 3 x + m \sin 5 x +$ &c.) where $I_0/A_0 = \sigma$, a constant, and x is any quantity which increases continuously. Thus it will be found that taking only one harmonic, $b = 0{\cdot}2$ gives a close approximation to what may be the actual case in transformer problems. Taking two harmonics, $b = 0{\cdot}2$ and $m = 0{\cdot}05$, gives a better result. There is no hysteresis in such cases.

3. If the curve is a simple hysteresis loop such as may be obtained in slowly performed cyclic magnetisation, on the assumption that $I = I_0 \sin x$, one of my students, Mr. Fowler, has found A in terms of $\sin (x + e_1)$, $\sin (2 x + e_2)$, &c., a rather complicated expression which I need not give. But another student, Mr. Field, finds that the approximation $A = A_0 \{ \sin (x + f) - b \sin 3 x + m \sin 5 x \}$ is sufficiently accurate for many purposes of calculation if $b = 0{\cdot}2$ and $m = 0{\cdot}05$. However complicated the law may be, it can be expressed in the shape: if $I = \Sigma I_i \sin (i x + e_i)$, then to the ith term in I, there correspond the terms in A, $(I_i/\sigma_i) \{ \sin (i x + e_i + f_i) - b_i \sin 3 i x + m_i \sin 5 i x +$ &c.$\}$

Our first assumption of constant permeability applied to a transformer with one primary and many secondaries causes equation (1) to become $A = (1 + q \sigma \theta)^{-1} N_1 V/R_1$, and hence

$$- C_s = (N_s N_1 / R_s R_1) \{ \sigma \theta V / (1 + q \sigma \theta) \}.$$

I will, for sake of illustration, consider a 1,500 watt transformer, which is a specimen of many in use. One primary coil $R_1 = 27$ ohms, $N_1 = 460$ turns. Internal resistance of the one secondary coil $= 0{\cdot}067$ ohm, $N_2 = 24$ turns. Effective primary potential difference $= 2{,}000$ volts or $V = 2{,}828 \sin k t$. Frequency about 95 per second, or $k = 600$, $a = 360$ square centimetres, $\lambda = 31$ centimetres. It will be found that the highest value of β, the induction per square centimetre, is $2{\cdot}755 \times 10^{-5}$ (or 2,755 C.G.S. units). If there are neither condensers, nor self-inductions, nor magnetic leakage, and if $\mu = 2{,}000$ (it will not much affect our results to take $\mu = 1{,}500$ or 3,000), then $\sigma = 3 \times 10^{-4}$; if there is no load on the transformer $q = 7{,}837$, and if there is full load, when $R_2 = 6{\cdot}8$ ohms, $q = 7{,}922$. It is evident from these numbers that in practical cases $1 + q \sigma \theta$ is nearly the same as $q \sigma \theta$. Neglecting the 1 means neglecting an alteration of $\frac{1}{3000000}$th of the amplitude and a lag of $\frac{1}{200}$th of a degree. We see that in this case neglecting the term A in equation (1) is quite allowable, and if such a transformer had one primary and many secondary circuits, we might at once write

$$I = N_1 V_1 / R_1 q \theta \qquad (2).$$

$$- C_s = N_s N_1 V_1 / R_s R_1 q \qquad (3).$$

Of course, with any law of magnetisation these are the answers if A may be neglected in equation (1).

Taking the third assumption, the simplest hysteresis cycle, which when $f = 0$ is also the second assumption. If $I = A_0 \sigma \sin k t$, (1) gives for V_1 the value

$$V_1 = \frac{A_0 R_1}{N_1} \{ \cos f \sin k t + (\sin f + q \sigma k) \cos k t - b \sin 3 k t + m \sin 5 k t \}.$$

If $k = 600$, or a frequency of 95 per second, the lowest value of $q \sigma k$ for the above-mentioned transformer is 1,411, so that taking f of any value whatever, and b and m even much larger than the values given above, it is obvious that for all practical purposes, certainly in the case where it is the effective value of V_1, which is important, the above expression for V_1 is the same as if f, b, and m were zero. No doubt V_1 does possess small traces of the higher harmonics, but taking the above values for b and m, and taking $f = 20°$, I find that the error in neglecting f, b, and m, in calculating the effective voltage, is utterly insignificant. I have applied to this problem the most complex law of magnetisation which I could formulate which was at all likely to be true, and in all cases I have arrived at the same result:—Given the voltage, V_1, at the terminals of a primary coil of a transformer with many secondary coils, the induction and the secondary currents may be calculated from (2) and (3), which were worked out on the assumption of constant permeability, and in all cases the error in the effective values is exceedingly small.

V. *Magnetic Leakage*.—If all the induction due to the current in any coil does not thread through all the other coils, the effect of leakage is obtained by assuming that each N is really less than the number of turns, and that there is some self-induction in each circuit in addition to $N^2 \sigma$. If the additional inductances are l_1, l_2, &c., then, in our expression R_1, R_2, &c., will be replaced by $R_1 + l_1 \theta$, $R_2 + l_2 \theta$, &c. Thus, in the above-mentioned 1,500-watt transformer, let I_0 represent the induction when there is no load on the transformer. Assume that 1 per cent. of the induction due to the primary current escapes the secondary, and that 1 per cent. of the induction due to the secondary current escapes the primary, or that $l_1 = 10^{-2} N_1^2 \sigma = 0{\cdot}6348$, $l_2 = 10^{-2} N_2^2 \sigma = 1{\cdot}738 \times 10^{-3}$. Let I be the induction at full load, or when $R_2 = 6{\cdot}8$ ohms. When there is no magnetic leakage $I = 0{\cdot}99 I_0$; when there is 1 per cent. magnetic leakage $I/I_0 = (1 + 2{\cdot}54 \times 10^{-4} \theta) / (1{\cdot}0108 + 5{\cdot}03 \times 10^{-4} \theta)$. Assuming I_0 to be $\sin k t$, I gives the value of I for various values of k.

* Royal Society. Received March 23rd, 1892.

k.	I.
100	0·988 sin ($k\,t$ − 1°·4)
300	0·981 sin ($k\,t$ − 4°·2)
600	0·958 sin ($k\,t$ − 8°·1)
1,000	0·912 sin ($k\,t$ − 12°·4)
2,000	0·782 sin ($k\,t$ − 18°·2)
4,000	0·628 sin ($k\,t$ − 18°·1)

VI. *Eddy Currents.*—There is eddy current loss of power in all the conducting masses near a transformer. If we assume that the induction per square centimetre β is the same everywhere, and if it follows the law β (in C.G.S. units) $= \Sigma\, a_i \sin(i\,k\,t + e_i)$, the average power in watts wasted in eddy currents in the iron per cubic centimetre is $6{\cdot}25 \times 10^{-18}\, r^2\, k^2\, \Sigma_i{}^2\, a^2{}_i$, if the specific resistance of the iron is taken to be 10^4. The iron is supposed to be of wire of radius r centimetres.

The average power wasted in the iron is less at high temperatures, being inversely proportional to the specific resistance of the iron. It is evidently proportional to the square of the effective primary voltage in the unloaded transformer, but, of course, magnetic leakage causes a diminution when the transformer is loaded. In fact, the eddy current loss is always proportional to the square of the effective electromotive force in the secondary circuit. In applying the rule, it is to be remembered that the induction is not uniform in the section of a wire, nor is the average induction in each wire the same for all the wires, and therefore the real loss of power in the iron by eddy currents is always greater than the result of applying the above formula.* If we assume that one secondary circuit closed upon itself represents all the eddy current circuits, assuming the truth of the above formula is the same as assuming no magnetic leakage between the primary and this eddy current circuit. Assuming magnetic leakage gives the more correct result, which is practically that the magnetisation is greater in wires near the surface of the mass of iron than it is internally, and also that the induction is greater near the skin of each wire.

Such experiments as have hitherto been made do not enable us to say to what extent the eddy current loss is increased by this cause. In the above-mentioned 1,500-watt transformer there is 10 per cent. less eddy current waste at full load than at no load, because of the change in q^2 and also because of magnetic leakage, and there may be 50 per cent. less eddy current waste due to the higher temperature of the iron.

VII. *Unloaded Transformer.*—When there is a fair load on the transformer, the primary current may be calculated on the assumption that the permeability is constant, without much, error. But when there is no load, or small load on the transformer it is necessary to know the law connecting A and I. Everybody who has studied this subject takes A in an unloaded transformer as being $N_1\, C_1$. Now, in reality, this is an assumption that there are absolutely no eddy currents; but as there are always eddy currents, however finely the iron may be divided, and even small eddy currents produce great effects upon C_1, the magnetic law which has been deduced from experiments on this assumption must be quite untrue. Taking eddy current effect as represented by a circuit (n, r) with no magnetic leakage; taking as our magnetic law that when $I = g\,\sigma \sin x$,

$$A = g\,(\sin x - b \sin 3\,x + m \sin 5\,x).$$

If V is a simple sine function of the time, I is so also with very great accuracy, but not perfect accuracy. Assuming that I is a simple sine function, the neglected terms in V may be calculated; this serves no useful purpose, so far as I can see at present, as they are so insignificant. The only problem of importance is really the calculation of C_1, assuming that with great, but not perfect, accuracy V has the value $V_0 \sin k\,t$. Our equations are $V = R_1\, C_1 + N_1\, \theta\, I$ and $0 = r\,c + n\,\theta\, I$, and hence $N_1\, V_1/R_1 = A + q\,\theta\, I$, where $A = N_1\, C_1 + n\,c$ and $q = N_1{}^2/R_1 + n^2/r$. Now n^2/r is negligible in comparison with $N_1{}^2/R_1$ in transformers, and we may take $q = N_1{}^2/R_1$. Hence $-I = (V_0/N_1\, k)\cos k\,t$ very nearly, and if $e = n^2\,\sigma\, k/r$, being called the eddy current effect, f being the hysteresis term,

$$C_1 = (V_0/N_1{}^2\,\sigma\, k)\left\{\sqrt{(1 + 2\,e\sin f + e^2)}\,\sin\left[k\,t - 90 + \tan^{-1}\left(\tan f + \frac{e}{\cos f}\right)\right] - b\cos 3\,k\,t - m\cos 5\,k\,t\right\} \qquad (4)$$

We see that the effect of eddy currents without hysteresis is to increase the amplitude of the fundamental term in C_1, and to produce a lead of $90° - \cot^{-1} e$, whereas the effect of hysteresis without eddy currents is to keep the amplitude unaltered, and to produce a lead f. If f is put equal to 0, that is if we assume no hysteresis, we obtain results which seem to be in accordance with such experimental observations as have yet been made.

The effective current C′ (if V′ is the effective voltage) with constant permeability is $V'/N^2\,\sigma\, k$; with hysteresis (or with no hysteresis but some saturation of the iron) but no eddy currents, $C' = 1{\cdot}02\, V'/N^2\,\sigma\, k$, taking b as 0·2; with eddy currents and hysteresis, $C' = V'\sqrt{(1{\cdot}04 + 2\,e\sin f + e^2)}/N^2\,\sigma\, k$.

The average power given to the choking coil or average value of $V\,C$ is $V'\,C'\,\dfrac{e + \sin f}{1 + e^2 + 2\,e\sin f}$, neglecting the small terms due to b and m.

Probably, in transformers there are always traces of the term in $3\,k\,t$, and the higher harmonics in both V and I, but they certainly must exist in either V or I, whether the transformer is loaded or unloaded. In the loaded transformer, magnetic leakage causes considerable diminution in the higher harmonics of I, and this may increase them in V.

It seems that in a choking coil with a finely-divided iron core, we have found what has been long looked for, a method of increasing frequency by mere magnetic means. A condenser shunting a non-inductive part of the circuit would receive currents in which the higher harmonics would be greatly magnified in importance. To show the magnitude of the terms in (4) I will take the above-mentioned 1,500-watt transformer, in which $q_0 = 7{,}783$. Taking $f = 0$ or no hysteresis, the power wasted in eddy currents being $n^2 V_0{}^2/2\, r\, N_1{}^2$, let this be 40 watts; then $n^2/r = 2{\cdot}1168$ when $V = 2{,}828$. The eddy current coil therefore which would replace all the eddy current circuits is a coil of two turns whose resistance is about 1·9 ohms, short circuited on itself.

$e = 0{\cdot}38$ if $k = 600$. Assuming constant permeability and no eddy currents and no hysteresis $C_1 = 0{\cdot}07398 \sin(k\,t - 90°)$, with some saturation and eddy currents, but no hysteresis.

$$C_1 = 0{\cdot}07911 \sin(k\,t - 69°{\cdot}2) - 0{\cdot}014796 \cos 3\,k\,t - 0{\cdot}003695 \cos 5\,k\,t,$$

I have taken $b = 0{\cdot}2$ and $m = 0{\cdot}05$.

The primary potential difference, V, is never a simple sine function of the time. Besides the important term in $\sin k\,t$, there are small terms of higher frequency, and at least one term of lower frequency equal to the number of turns of the armature per second. The tendency of the forces acting on coils in series on an armature is to produce greater dissonance at greater loads, but it may be assumed that in good machines the fastenings are sufficiently rigid, and the coils and pole pieces so nearly alike, that there is always very little dissonance.

The primary potential difference, instead of being $2{,}828 \sin 600\,t$ in the above case, may be

$$V = 100 \sin 20\,t + 2{,}823 \sin 600\,t + 200 \sin 1{,}800\,t,$$

the effective potential difference, as measured by a voltmeter, being the same in the two cases. The induction, if there is no magnetic leakage, will be

$$-I = (N_1/R_1\, q)\,(5\cos 20\,t + 4{\cdot}7\cos 600\,t + 0{\cdot}11\cos 1{,}800\,t),$$

the term which was so insignificant, which had only $\frac{1}{500}$th of the importance of the most important term in practically estimating the volts, is now greater than what is usually taken to be the greatest term when we come to deal with the actual induction. Magnetic leakage will not much affect this condition of things, but it will greatly diminish the importance of the higher harmonics.

When experimenters say that they keep the primary volts constant, they mean that they keep the effective primary volts constant. It is obvious from the above considerations that different methods of keeping effective volts constant will produce very different kinds of induction. The effects produced by an exciting current in a choking coil or unloaded transformer are evidently very complicated. Let the dynamo have a perfctly pure simple harmonic law of electromotive force; we have seen that even when no hysteresis is assumed, the current will possess large harmonics and the induction possesses corresponding harmonics. The energy wasted in the creation of these harmonics may be called "hysteresis" loss, but it cannot be altogether the same as the hysteresis loss in slowly performed cycles of magnetisation; it will be different if the dynamo does not follow a simple harmonic law in its electromotive force, and the apportioning of the smaller higher harmonics to the primary voltage and to the induction must greatly depend upon the self-induction of the dynamo machine.

* *Added April* 29th, 1892.—I have often urged the importance of the consideration of the want of uniformity of induction in the iron; but even in February last, when I brought it before a meeting of the Institution of Electrical Engineers, it was looked upon as unimportant, and I had made no calculations which would enable me to prove its importance. The calculations of Prof. J. J. Thomson concerning the eddy currents in thin plates, published in *The Electrician* of April 8th, 1892, place the matter beyond doubt.

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

"ON THE CAUSE OF THE CHANGES OF ELECTROMOTIVE FORCE IN SECONDARY BATTERIES," by J. H. GLADSTONE, Ph.D., F.R.S., Member, and WALTER HIBBERT, F.I.C., Associate, read on Thursday, May 12th, 1892.

(*Continued from page* 675.)

This evidently is the tale that is told by fig. 4. Beginning with an external acid of 24·6 per cent., and a corresponding E.M.F. of about 2·03 volts, there is a rapid rise—so rapid, indeed, that by the end of half an hour the E.M.F. has become 2·1 (which is about equal to what would be given by a 40 per cent. acid at each plate, see fig. 3), whilst the intermediate acid has not risen, but is only 24·5 per cent. The increase of E.M.F. due to increase of strength of acid against the plates then becomes very slow; but after about nine hours it is found to have risen to what we may look upon as 45 per cent. or more, against the $Pb\,O_2$ plate, while the intermediate acid in the cell has risen to 27 per cent. It subsequently rises against the working surfaces of the plates to 55, and eventually to at least 66 per cent., or probably much more, though the strength is little increased in the body of the cell.

When discharge commences, we have shown that there must be a very rapid weakening of the acid from diffusion and formation of lead sulphate, till the losses are fully counterbalanced from the intermediate acid. There will then be no material reduction till the

intermediate acid is considerably reduced or prevented diffusing freely into the pores of the plates. This is the explanation of fig. 5. We see the rapid fall of E.M.F., the bulk of which takes place in the first few minutes (see Ayrton and others, pp. 545 and 546, and our experiments, fig. 1). After about half an hour the E.M.F. is reduced to about 2·03 volts, indicating about 25 per cent. H_2SO_4 against the plates, while the intermediate acid is 27·8 per cent. This state of things lasts for some hours, but the absorption of the free acid that is in the pores of the plates gradually reduces the strength there below that of the intermediate liquid, so that after eight hours the internal acid is about 22 per cent., while the external strength has sunk only to about 26 per cent. The acid against the plates then declines more rapidly, so that in four hours more the E.M.F. is equal to that which would be given by 7 per cent. at each plate, while the intermediate acid has scarcely sunk below 25 per cent.

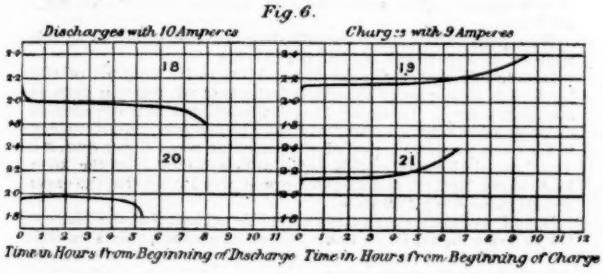
We have already mentioned in Section I. that when the acid is very weak the compound 2 $PbSO_4$. Pb O may begin to form. Should this be the case, the acid absorbed per ampère hour would be less than before by about one-third. This is about what was found by Dr. Frankland, and described by him in the discussion on the paper by Prof. Ayrton and his colleagues (*Jour. Inst.*, xix., 698). Dr. Frankland shows that in some prolonged discharges there was some such reduction of the absorbed acid, and that the diminished rate of absorption began when the voltage fell below 1·8—a figure indicative, on our hypothesis, of a weak acid in the pores of the plates.

We have also shown that if through prolonged discharge the acid in the pores has become very weak, a stoppage of the discharge ought soon to bring up the acid towards what it is outside. The E.M.F. ought therefore quickly to increase to the normal, or nearly so. This rise after rest was observed in very early days, and has been frequently discussed, as, for example, by Messrs. Gladstone and Tribe ("Chem. Secondary Batts.," p. 28), and by Prof. Ayrton and others.

We have already seen that if a charged cell be allowed to rest without discharge, the acid in the interstices of the Pb plate is slowly weakened by its action on the lead with the evolution of hydrogen gas. The gas will tend to clog the interstices and impede the stronger acid outside from diffusing inwards.* The lower strength of internal acid will produce a lower E.M.F. than would be obtained if the internal acid were of the same strength as the external. In other words, a discharge after long repose ought to commence with a somewhat low E.M.F. But one effect of discharging will be to remove the impediment to free diffusion produced by the enclosed gas, and thus tend to increase the strength of the internal acid, with a consequent small rise in E.M.F. as the discharge goes on.

Now Professor Ayrton and his colleagues obtained these very results in two instances. The curves representing one of these we have reproduced (fig. 6) from their paper, with two previous normal curves, *a* and *b*, for comparison.

Fig. 6.



In both the instances not only had the P.D. sunk below the normal during repose, but it never quite recovered its normal value, while the fall towards the end of the action took place in about two-thirds of the normal time. On subsequent charging, the process of decomposing the $PbSO_4$ lasted for only two-thirds of the usual time. All this points to an early clogging of the pores, and a consequent diminution of the total chemical action.

In this way we explain what the discoverers of the effect regard as a difficulty. The real problem that had to be solved was not, why did the P.D. go up during discharge? but why had it gone down during the many days' repose?

PART IV.—CONFIRMATIONS, THEORETICAL AND EXPERIMENTAL.

1. *Changes of E.M.F. with two Similar Plates.*—In the discussion that followed one of our papers at the Physical Society, Mr. Hibbert mentioned that if two lead plates are put into acids of different strengths, separated by a porous diaphragm, a voltaic current is produced on completing the circuit.† We have performed this experiment on two lead plates quantitatively, with reference to the E.M.F. produced, and have extended the observations to two peroxide plates.

The method of experimenting was as follows:—A divided cell was taken, in one compartment of which was placed sulphuric acid of about 0·2 per cent., in the other an acid varying from this strength upwards.

A pair of lead plates was tested in the weakest acid in order to ascertain that when immersed in the same liquid they gave no appreciable E.M.F. One of the lead plates was then put into a stronger acid, and the E.M.F. between it and the other determined by the condenser method. This was continued up to a 98 per cent. acid, but, as the stronger acids act freely on spongy lead, the observations beyond 22·5 per cent. were made with two solid lead wires.

The results are given in the following table. The lead plate in the *weaker* acid behaved all through like a PbO_2 plate to the other, and it is therefore called the + plate.

TABLE VI.

Acid round + lead plate.	Acid round − lead plate.	E.M.F. in volts.
Per cent.	Per cent.	
0·2	0·65	0·036
"	1·35	0·047
"	2·85	0·060
"	5·5	0·066
"	10·5	0·082
"	14·5	0·094
"	18·0	0·102
"	22·5	0·109
"	36·5	0·150
"	48·0	0·164
"	57·5	0·204
"	85·5	0·247
"	98·0	0·266

A similar series of experiments was made with two peroxide plates It is not likely, however, that the 99 per cent. acid had completely soaked into the meshes of PbO_2. The peroxide in the *weaker* acid behaved like a lead plate, and is therefore called the − plate.

TABLE VII.

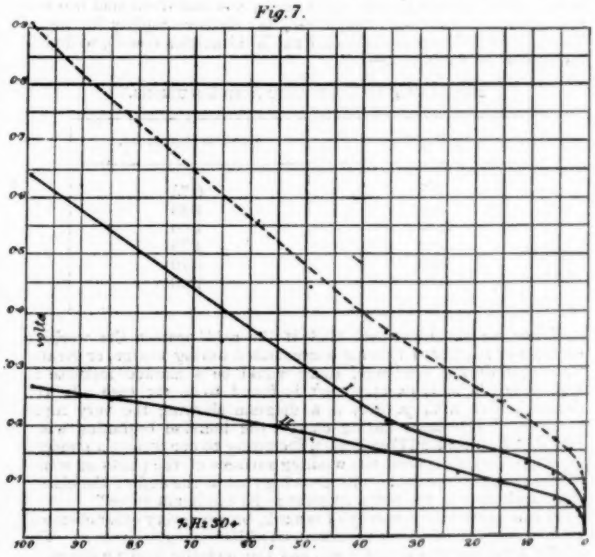
Acid round − PbO_2 plate.	Acid round + PbO_2 plate.	E.M.F. in volts.
Per cent.	Per cent.	
0·2	0·65	0·054
"	1·35	0·072
"	2·85	0·095
"	5·5	0·107
"	10·5	0·134
"	14·5	0·150
"	18·0	0·158
"	22·5	0·168
"	36·5	0·215
"	48·0	0·281
"	57·5	0·359
"	85·5	0·537
"	99·0	0·643

The results are delineated in the following diagram:—

If we consider Curve I. in Fig. 7—which shows the E.M.F. between two *peroxide* plates, one of which stands in sulphuric acid of only 0·2 per cent., and the other in strengths varying from that to 99 per cent.—we see at once that, while it rises through 0·589 volt, it is far from being a straight line. It rises very rapidly at first, then bends over and remains convex till about 18 per cent. is reached, when it becomes somewhat concave till about 57 per cent., after which it is tolerably straight.

If we consider Curve II., fig. 7—which shows the E.M.F. between two *lead* plates, one of which is in the weak and the other in stronger

Fig. 7.



acids—we find that it follows a similar course, but the ordinates are only about two-thirds as large up to about 30 per cent., after which they are relatively much less.

* There may also be a slow formation of lead sulphate on either plate, due to the local action described further on.

† *Electrician*, Vol. xxvi., p. 154.

In Curve II., fig. 2, we have an experiment in which the peroxide plate was placed in various strengths of acid, while the lead plate was retained in acid of uniform strength, namely, 14 per cent. The observations are only from 6·5 per cent. to 81 per cent., but on comparing it within those limits with Curve I., fig. 7, it will be at once seen that the curves are identical in form. They are also identical in the absolute amount of the rise. The difference between 6·5 per cent. and 81 per cent. in Curve II., fig. 2, is 0·404 volt; whilst in Curve I., fig. 7, the difference is 0·401 volt.

In fig. 3 we have also observations on a cell with the Pb O_2 plate in various strengths of acid from 43·5 to 88·5 per cent., while the Pb plate remains in acid of 27 per cent. On comparing this with the similar portion of the curve in Curve I., fig. 7, we find that in both instances we are dealing with a line which is very nearly straight. The rise of E.M.F. in fig. 3 between the points mentioned is 0·307 volt, and in fig. 7 it is 0·308 volt.

The close similarity both of the forms of the curves and the amount of the rise in each case, shows that the causes of the phenomena represented in figs. 2 and 3 are the same as those in fig. 7, within the range of the experiments. There is, however, this essential difference in the experiments—that while in figs. 2 and 3 we are dealing with a peroxide plate and a lead plate, in fig. 7 we are dealing with two peroxide plates, and the results can be dependent only on the varying strength of acid. This, of course, is a strong confirmation of the theory we have propounded.

It is worthy of note that in the three experiments just compared together, the strength of the unchanged acid round the − plate was very far from being the same, varying, in fact, from 14 per cent. in fig. 2, and 27 per cent. in fig 3, to 0·2 per cent. in fig. 7. In other words, it does not matter what may be the starting point. This is just what might be expected if we are dealing merely with a differential result.

If we compare Curve I., fig. 7, with the lower part of fig. 3, we observe a general resemblance, but with well-marked differences. In each case there is the rapid rise at commencement, with the subsequent bend over and convexity. But in fig. 3 the concavity has nearly disappeared. There is also another difference. The rise in this case between 6·5 per cent. and 49 per cent. is 0·251 volt, instead of 0·183 volt in fig. 7.

These differences are easily explained. It will be remembered that the curve of fig. 3 represents the variation of E.M.F. due to increasing strengths of sulphuric acid about the peroxide and the lead plate at the same time; while Curve I., fig. 7 represents the increasing E.M.F. due to increased strength of sulphuric acid solely at the + Pb O_2 plate. In Curve II. of fig. 7 we have, however, the E.M.F. due to increasing percentages of sulphuric acid round a − Pb plate. Now it has already been stated that increasing the sulphuric acid round the two plates acts in opposite directions in the two cases, so that the potential difference between them in any particular acid will be the arithmetic sum of the separate effects. We have therefore added the two curves of fig. 7 together and obtained the dotted curve, fig. 7. It will at once be seen that this combined curve closely resembles the experimental curve in fig. 3, the concavity having almost disappeared. The rise from 6·5 to 49 per cent. has become 0·27 volt, only slightly exceeding that of the curve in fig. 3, namely, 0·25 volt.

We have thus resolved the rise and fall of E.M.F. during the charge and discharge of a cell into the two parts of which they are composed, and have determined them quantitatively.

2. *Confirmatory Evidence from Changes in Resistance.*—The general correctness of the conclusions arrived at in Part III. is supported, not merely by the known changes in E.M.F., but also by changes in resistance as given by Professor Ayrton and his colleagues.

It is a matter of common knowledge that sulphuric acid varies very much in resistance according to its state of hydration; that the resistance is least for acid of about 30 per cent., though not changing very widely between 15 and 50 per cent.; and that if the acid become either weaker or stronger than these, its resistance rapidly increases. The following figures, calculated from Kohlrausch's results, will give an idea of the variation:—

RESISTANCE OF SULPHURIC ACID SOLUTIONS.

% H_2 SO_4.	Relative Resistance.
2·5	6·73
15·0	1·33
30·0	1·00
50·0	1·35
71·0	3·79
95·0	7·29

Hence we should expect that if the acid against the working surfaces of the plates is being concentrated during charge, or greatly weakened during discharge, there would be a marked increase in resistance. This is exactly what is found to be the case. In the *Journal*, Vol. xix., p. 590, is a diagram showing the very rapid increase of resistance during charge, the increase beginning when the E.M.F. (about 2·17) indicates, according to our theory, a strength of sulphuric acid against the working surfaces of the plates of somewhere about 50 per cent.; also showing that at the end of the charge "the resistance is five times as great as its minimum value."

This is particularly worthy of remark, because every other chemical change would tend to diminish, instead of increasing, resistance. The Pb O_2 produced on the one plate, and the metallic lead produced on the other, are both much better conductors than the Pb SO_4 which they replace.

On page 592 of the same volume is another diagram, showing that when the discharge of this cell was begun the E.M.F. had fallen from 2·30 to 2·06 volts; and the resistance, which at the end of the charge was 0·0115 ohm, had fallen to 0·0038. We attribute both these falls to the same cause, namely, the reduction of the internal acid to about 30 per cent. Subsequently, the E.M.F. slowly diminished, while the resistance remained nearly the same for about five hours, when the E.M.F. more rapidly fell to 1·95 volts, and the resistance rose to 0·0055 ohm.

This is more than would be expected from the above table of resistances, but it must be remembered in this case that the other chemical changes—that is to say, the conversion of Pb O_2 and Pb into Pb SO_4, would also tend to increase, instead of diminishing, the resistance.

We do not lay great stress on precise numerical relations in the case of resistance, as the change in the strength of the acid at the working surfaces is only one of the factors, though an important one.

3. *Confirmation from Mr. Crompton's Experiments.*—During the discussion on the papers by Professor Ayrton and his colleagues, Mr. Crompton described two series of experiments which have a bearing on this subject.* In the first series some cells were discharged at rates varying from 11 to 66 ampères, and Mr. Crompton found that the ampère-hours delivered with a given range of P.D. fell from 300 to 125. He adds: "In every case the form of the curve is very definite, the turn-down as soon as the electromotive force falls to 1·8 being very marked."

This follows naturally, because at the higher rate of discharge the absorption of the acid in the pores has become much quicker, while the diffusion is scarcely affected, so that the weakening process goes on much faster. The critical voltage of 1·8 simply indicates that the internal acid has become very weak. Mr. Crompton's curves and remarks show clearly that the fall is independent of the amount of Pb O_2 remaining on the plate.

In the second series of experiments thicker plates were used, and then he found a greater diminution of delivering capacity at the higher rates of discharge—in fact, it fell from 300 to 90-ampère hours, and at the highest rate the fall began almost at once. This must be the natural result of the greater distance through which the entering acid has to diffuse.

4. *Confirmation from Thermo-Chemistry.*—It is possible to test the matter further by applying Lord Kelvin's law as to the relation between the E.M.F. of a cell and the thermal value of the chemical actions contributing to it. We hope to go into this matter more fully, and shall content ourselves at present with pointing out that the liquid in a secondary cell is a mixture, or a chemical compound, of two different liquids—sulphuric acid (H_2 SO_4) and water, in varying proportions.

The simple problem is to determine what would be the voltage of a Pb O_2 — Pb cell in which there was nothing but pure H_2 SO_4.

From the thermo-chemical data which are before us we arrive at the value of 2·627 volts. Our own determination, by means of the closest approximation which we could make to absolute H_2 SO_4, is 2·607 volts.

With pure water only in the cell, the calculated value is 1·35 volts, whilst in an experiment we found 1·36 volts.

In determining the thermo-chemical values for mixtures of these liquids, it is necessary to subtract the heat of dilution from the available energy. On doing this, the calculated and experimental numbers do not agree so well as those already given, until we come to the most prominent part of the curve at about 6 per cent. acid. The theoretical value at this point, as determined from the known heats of combination and dilution, would give 1·901 volts, the experimental value being 1·89 volts.

With lower figures than 6 per cent. it is evident that the change is not to be accounted for on thermo-chemical grounds, unless we admit a change in the chemistry as we approach pure water—a conclusion already drawn from other data.

It is now easy to understand the large P.D. required for charging an accumulator. The current has to do extra work in concentrating H_2 SO_4 at the Pb O_2 plate, and the energy equivalent to that work must be obtained from an increased P.D. For a dyad gramme equivalent of H_2 SO_4 concentrated from a 10 per cent. solution to 100 per cent. about 17,000 calories will be needed, and this = 0·37 volt. The calculated charging E.M.F. must therefore be at least 2·3 volts.

PART V.—CONSIDERATION OF OTHER SUGGESTED CAUSES OF THE VARIATION OF E.M.F.

As other causes have been suggested for the changes in E.M.F., it is desirable to consider how far they are in accordance with the known facts of the case. It is evidently possible that the phenomena may be due to a number of causes co-operating.

1. It might be supposed that the reduction of the E.M.F. in discharge is determined by the relative amount of lead peroxide which is destroyed or covered over with sulphate of lead.

This is absolutely disproved by the experiments of Professor Ayrton and his colleagues, which are graphically represented in figs. 1 and 2, given on p. 661, Vol. xix. of the *Journal of Electrical Engineers*. It will there be seen from the determinations of the percentage Pb O_2 found on plugs removed, that the formation of the Pb O_2 in charging, and the decomposition of it in discharging, is a fairly regular and continuous action. It gives no indication of the rapid changes at the commencement and termination of charging and discharging; while during the intermediate period, when there is little change of the E.M.F. for many hours, the rate of variation in composition is steady. This is indicated, as far as the discharge is concerned, by the dotted line in our fig. 4, which is reproduced from the paper by Messrs. Ayrton, Lamb, Smith, and Woods. (See also remarks on Mr. Crompton's experiments, *ante*.)

2. Planté considered that the exceedingly high E.M.F. observed for

* *Jour. Inst. Elec. Engineers*, Vol. xix., pp. 691, 692.

the first few minutes on joining up a completely formed cell, immediately after its removal from the charging circuit was due to the gaseous hydrogen found on the Pb plate. Gladstone and Tribe,* while considering that this was possible, drew attention rather to the hydrogen occluded by the lead as a possible cause, but stated at the same time that this occluded hydrogen was exceedingly small in quantity. Frankland showed by a totally different process that it was practically *nil*.

But hydrogen on one plate and ozygen on the other would not, under the conditions, account for as much as 2 volts, and this explanation is therefore inadequate.

3. Planté observed that a small quantity of lead peroxide is formed on the Pb plate during discharge; and Gladstone and Tribe found in this a reason for the state of electric equilibrium being approached before the peroxide on the Pb O_2 plate is exhausted, and also for the fact that partly discharged accumulators give an increased current after repose ("Chem. of Sec. Batts," pp. 27, 28). This last action is attributed to the extreme rapidity with which the lead peroxide formed on the Pb plate must be destroyed by local action.

Mr. Robertson has recently added to this the observation that the formation of peroxide of lead on the Pb plate does not take place till the E.M.F. has fallen much below the normal value.†

We have already attributed the resuscitation of the E.M.F. on repose to the inflow of the stronger acid to the acting surfaces of the opposed plates, but we must look upon this formation of peroxide of lead, where it does occur, as contributing both to the reduction of E.M.F. and its resuscitation.

4. *Presence of some Form of "Active Oxygen."*—It is well known that electrolised sulphuric acid contains some hydrogen dioxide, which is probably due to the decomposition of per-sulphuric acid by water.

Gladstone and Tribe showed that the presence of hydrogen dioxide in a cell must reduce the peroxide of lead—an observation confirmed by Robertson (*Proc. Roy. Soc.*, Vol. 1., p. 107).

Last June, both Mr. Robertson and Prof. Armstrong communicated papers to the Royal Society, in which they attach great weight to the presence of peroxides in the electrolyte, as causing a loss of efficiency. As only abstracts of these papers are published as yet, we cannot enter into any criticisms of their experiments. Mr. Robertson, however, in a lecture to the Society of Arts (*Jour. S. A.*, xl., p. 44), states that the "variations in E.M.F. appear to depend on which plate hydrogen dioxide is found at. When present at the peroxide plate it causes a rise, but when diffused through the acid and present at the lead plate, it causes a lowering of the E.M.F."

We therefore made several experiments with the addition of hydrogen dioxide (both ordinary, and carefully purified from hydrochloric acid). Our arrangements admitted of adding the hydrogen dioxide to the electrolyte surrounding either the peroxide or the lead plate. Some of the determinations of E.M.F. were made by a condenser, and others by observing the current through an astatic galvanometer in series with a high resistance.

We generally obtained a slight reduction (about 0·02 of a volt), but only what might be fairly attributed to the dilution of the sulphuric acid.

It was still possible that some other form of "active oxygen" might accomplish what hydrogen dioxide had failed to do; and in order to determine whether these peroxidised products of electrolysis have really a different effect at the cathode and anode, we completed the charging of a pair of plates in a divided cell filled with 20 per cent. acid, and found that the "peroxides," or "active oxygen," existed only round the Pb O_2 plate. We then reversed the plates in the compartments, so that the Pb plate stood in the liquid containing the peroxides (H_2 O_2, persulphuric acid, &c.). One minute after stopping the charging current, and immediately before the reversal of the plates in the cell, the E.M.F. was 2·185 volts. After the reversal of the plates, the E.M.F. was measured by potentiometer at intervals, the results being given in the following table:—

Time after Reversal of Plates.	E.M.F. in Volts.
Minutes.	
1	2·163
6	2·081
8	2·078
10	2·066
12	2·063
15	2·055
22	2·044
45	2·031

There was evidently here no unusual fall in the E.M.F. The figures are embodied in the dotted curve of fig. 1, and on comparing it with the fall for 18·5 per cent. acid they will be found so similar as to show that peroxidised compounds round the Pb plate had no visible effect. In each case the voltage evidently fell very slowly to a uniform value, and that value agrees very fairly with what we find for a 20 per cent. acid in fig. 3. Through the kindnesss of Dr. H. Marshall, we were able to test the effect of adding some persulphate of potassium to the sulphuric acid in a cell about the Pb O_2 plate, but without visible effect on the E.M.F. As far, therefore, as our own experiments are concerned, the E.M.F. appears to depend on the acid strength of the electrolyte, and not on the existence or the position of any peroxidised bodies dissolved in it.

* "Chemistry of Secondary Batts.," p. 48.

† Robertson's report to Prof. Ayrton, &c., *Journal Institute Electrical Engineers*, Vol. xix., pp. 670—675.

ADDENDUM.

Although we did not undertake this investigation with the object of improving secondary batteries, there is one suggestion we should like to make—*i.e.*, the desirability of promoting diffusion as much as possible. We believe that this is becoming more and more the practice among those who make accumulators, and the previous considerations furnish three reasons for such a procedure.

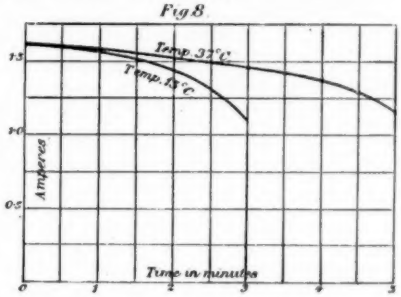
It is well known that the accumulation of stronger acid at the lower part of a cell during its working is disadvantageous. This is believed to create differences of current density in different parts of the plate, and we have shown that it will also give rise to potential differences of fairly large value on each of the plates, and thus produce local action and the formation of lead sulphate. This inequality would be diminished if the diffusion of the acid could be promoted.

The fall of E.M.F. at the close of discharge leaves a large fraction of the effective material not acted upon. This is mainly due to the weakness of the acid against the plates on account of the interstices being so much clogged; and it would be counteracted to a considerable extent if the diffusion could be increased.

When a cell has been discharged at below 1·8 volts, there occurs the destructive action called "scaling." We are disposed to attribute this to abnormal chemical action arising from the very weak acid; and if this be true, increased diffusion would in this case also act as a remedy.

Such increased diffusion might be obtained either by agitation or by heating, and we thought it interesting to try the effect of higher temperature on the output of our small cell. The following curve (fig. 8) exhibits the result of one experiment:—

Fig 8.



The discharge curves at the higher temperatures generally showed an output some 40 to 50 per cent. greater than those at the lower. But it is evident that the higher temperature would increase local action and the chemical action of the acid upon the spongy lead. This might be met by a reduction in the strength of acid, but we have not tested at what temperature and with what strength the advantage is at a maximum.

In addition to this suggestion, electricians will doubtless be able to make other useful applications of our conclusions that the changes of E.M.F. in a secondary battery depend on the strength of the acid that is against the working surfaces of the plates.

FINAL HEARING ON EDISON'S "FEEDER AND MAIN" PATENT FOR ELECTRICAL DISTRIBUTION.—I.°

THE suit of the Edison Electric Light Company against Westinghouse, Church, Kerr & Co. for an alleged infringement of Edison's patent of September 19th, 1882, No. 264,642, covering the use of feeders in a system of electrical distribution, came up for argument on final hearing before Judge Green in the United States Court, at Trenton, New Jersey, on May 9th. Messrs. S. B. Eaton and F. H. Betts appeared as counsel for the Edison Company, and Messrs. E. Wetmore and L. E. Curtis for the Westinghouse Electric and Manufacturing Company, the real defendant in the case. The suit was originally brought on December 22nd, 1886, and alleged an infringement of the patent by reason of the construction and operation of a lighting plant in Trenton, N.J., constructed by Westinghouse, Church, Kerr & Co. during the summer of 1886. Most of the evidence taken in the case has consisted of expert testimony of a somewhat technical character. Among the experts of note who have been employed by the complainant are Prof. C. F. Chandler, and Messrs H. R. Brevoort and W. J. Jenks. The complainants also took by commission at Glasgow the evidence of Sir William Thomson. The experts for the defence were Prof. Henry Morton, Franklin L. Pope Benjamin S. Church, and others.

The arguments of counsel on both sides have occupied some seven days. The importance of the issue involved is scarcely less than that of the lamp case recently heard in the Circuit Court of Appeals in New York. No small part of the time was necessarily occupied in efforts to instruct the presiding judge as to the force and effect of the technical term employed in the patent, and the scientific matters which are presumably so familiar to readers of this journal that it is scarcely necessary to occupy space in attempting to give a synopsis of the arguments. We have therefore attempted to summarise the leading points upon which the counsel for the complainant and defendant seemed to have principally relied in the presentation of the case in order that its merits may be understood. Certain preliminary questions were brought up by a motion to dismiss the bill which had

° *Electrical Engineer*, New York.

reference to the capacity of the parties and the jurisdiction of the court, but as these have really nothing to do with the merits of the case, we shall make no further reference to them.

The general purpose of the invention as stated in the specification is as follows:—

"This invention relates to a method of equalising the tension or pressure of a current through an entire system of electric lighting or other translation of electric force, preventing what is ordinarily known as a drop in those portions of the system the more remote from the central station."

The specification then describes the arrangement and construction of the conductors by means of which the patentee proposes to obviate this difficulty and which constitutes the invention sought to be patented. This will be understood sufficiently from the following passage in the specification:—

"To obviate the difficulty, I provide feeding conductors which extend from the generator or generators to the main conductors of the lamp or consumption circuit or circuits, such feeding conductors not having any translating devices connected therewith, and being connected with the main conductors of the consumption circuit or circuits at the centre, ends, or other points on such main conductors."

The specification states in substance that the circuit consists of two essential parts, first the feeding conductors, and second the main conductor of the consumption circuit. This will be recognised as the usual arrangements of feeders and mains in all systems of electrical distribution, in which the conductors radiate from a central station and serve a district of any considerable size. The claims of the patent which are alleged to be infringed by the defendants are as follows:—

1. A consumption circuit, in the main conductors of which the drop in tension is not sufficient to vary practically the candle-power of the lamps connected therewith, in combination with feeding conductors connecting the consumption circuit with the source of electrical energy, and having no translating devices connected therewith, the drop in tension upon such feeding conductors not affecting the relative candle-power of the lamps of the consumption circuit, substantially as set forth.

2. A consumption circuit in the main conductors of which there is a definite small drop in tension not sufficient to vary practically the candle-power of the lamps connected therewith in combination with feeding conductors and having no translating devices connected therewith, the loss upon such feeding conductors being greater than upon the main conductors of the consumption circuit, substantially as set forth.

3. The combination of a consumption circuit, in the main conductors of which the drop in tension is not sufficient to vary practically the candle-power of the lamps connected therewith, with a feeding circuit having no translating devices, and extending from the source of electrical energy to the centre of the consumption circuit, substantially as set forth.

THE COMPLAINANT'S CASE.

Ten or twelve years ago, says the complainant, *i.e.*, 1879-80, domestic electric lighting was an achievement long sought and ardently hoped for but theretofore unattained. To-day every important town in this and other countries is equipped with thousands of incandescent lamps, in shops, public buildings and dwelling houses, all supplied from a common source. Some mind or minds, some one's ingenuity, or skill, or enterprise, has wrought this change. The problem which had to be solved was one which, 12 years ago, was popularly known as "subdivision of the electric light." It was a different problem from that of the production of a single light from a source of electric energy. It would be too much to contend that this achievement is wholly due to any one invention, or to any one man; but the present invention was at least a notable contribution to the solution of the problem. There were inherent difficulties in both the series and multiple arc system, when applied to extensive distribution to a number of lamps. In 1879 the whole subject of electric lighting had been examined with care by a Parliamentary Commission of Great Britain, at which time the evidence of many prominent scientists served to give some idea of the nature of the difficulties to be encountered. Mr. Edison's plan of using the high resistance lamp with a platinum filament, and of distributing current through it by branches radiating from a common trunk, was known as early as 1879. On January 27th, 1880, he patented his carbon filament lamp. He described the general features of his intended system of distribution in an application filed August 9th, 1880, and patented March 22nd, 1881. The present invention is outlined in a caveat filed August 19th, 1879, and disclosed in the application for the patent in suit filed August 9th, 1880. The difficulties in the way of dealing successfully with electrical energy under the conditions involved in wide distribution, arises from the fact that all conductors offer some resistance to the propagation of electric energy, and this resistance occasions the change of electric into heat energy. This conversion takes place throughout any system, but is only useful at the particular points where heat and light are to be made useful and sensible; everywhere else the conversion, though inevitable, is useless, and hence an absolute loss. The problem, as seen by Mr. Edison, therefore was: (1) to concentrate and localise as much as possible the operation of lowering the potential at points where, if useless, it would not affect anywhere the quality of work to be done, and if useful, it would be utilised; and (2) as far as possible to prevent its occurrence in other parts of the system. The ideal mode, theoretically, would be to have conductors of infinite size, except at points where obstruction is desired for the production of heat and light; but this is not a feasible remedy, because the cross-sectional area of conductors would necessarily be so large, as to involve a prohibitory expense. Moreover, if the whole system be an extended one, and be utilised for consumption throughout, and unless the conductors be so large that no loss in tension ever occurs (which is impracticable), then it is obvious that a variable drop in tension, due to variations in the amount of energy translated, will effect very differently, at different times, different lamps in the system. Now, Mr. Edison reasoned that if economy of copper is not practised between any lamps, but only in such parts of the conductors as do not affect the relative candle-power of the lamps, then distances may be reached with economy of copper, which are otherwise inaccessible.

The field of the present invention lies between two classes or systems of distribution; one where drop in tension need not be practically considered at all, and the other where the system is so extensive that the size of conductors required to supply it with equal pressures throughout would have to be approximately infinite.

Comparing the second and third, with the first claim of the patent, the latter are subordinate in character to the former, and introduce special features of construction included under, although not required by, it. The second claim requires a definite small drop in the consumption circuit, and that the drop on the feeder shall exceed that of the consumption circuit. The third claim requires the connection at the feeders to be at a central point on the consumption circuit. The system described and claimed in the patent is an extended system of electric incandescent multiple arc lighting, of such dimensions that the distances between the lamps prohibit their supply from one end of a direct circuit, because the drop in tension or the amount of copper required between the lamps would be too great, and also one in which, for purposes of maintaining equal potential at the terminals of all the lamps and notwithstanding the existence of excessive drop in the tension in the system as a whole, that drop is localised where it does not affect the lamps. These characteristics of the Edison system of distribution involve essential characteristics of novelty, and are believed to have required the exercise of the inventive faculty for their original production. That the invention is one of great utility is conceded on all hands. The system of the patent in suit was the first practical central station system ever constructed in the world. It was embodied in the New York installation, commenced in the fall of 1881 and opened for operation September 4th, 1882, originally calculated to supply 16,000 lamps. The drop in tension was calculated to be about 15 per cent. on the feeders, and not to exceed 3 per cent. on the mains.

The bill charges that the erection of the infringing central station plant by the defendant was done not only in defiance of the patents of the complainant company, but by taking from the employ of the complainant, and making use of the service of, many *employés* and experts, whom the complainant had trained in the construction and operation of such plants. When complainant's original *prima-facie* case was closed in January, 1890, complainant relied upon having proved infringement of the first and third claims, and this was admitted by defendant's experts. Facts were subsequently proved which tended to show beyond question that all three of the claims had been infringed.

The Supreme Court of the United States has commented upon the impossibility of making any satisfactory definition of what constitutes invention. A goal is to be reached, and keen eyes peer in every direction through the mists of surrounding ignorance and uncertainty for any signs of approach to, or the direction of, such goal. He, who under such circumstances notably excels his fellows in speed, or who, stepping out of the supposed line of journey, first perceives that it is to be reached by a new, even if only slightly divergent road, and who thereupon points out the right way, is, in a true sense, an inventor who has promoted the progress of the useful arts. The existing difficulties of the situation, actual or supposed; the mists of ignorance, error, or prejudice, then obscuring the vision, are to be taken into account in determining whether or not his finding of the true path was only what everyone might have done if called upon. In this characteristic of the seeming obviousness of the greatest inventions when once made, they do but resemble the deepest revelations of mental consciousness; as soon as they are stated, they are seen to be so obviously true, that it is a matter of wonderment that they had not been stated before. In the present instance the problem was not merely that of conveying electricity to a distance, and there causing it to be converted into many lights; it was rather to reach and properly supply all parts of a multiple arc system, some lamps of which were so remote, and others so near, that the whole could not be supplied in a direct circuit, and, moreover, to do this without sacrificing substantial equality of potential, and without exceeding practical limits of cost. The remedy lay in a perception of the fact that the distribution could not be practically accomplished without dividing the circuit into two parts.

The question now presented is whether, in the years 1879-80, the means of attainment devised and pointed out by Edison were obvious. A person skilled in the art, at a given time, is perhaps, in law, presumed to have knowledge of all that had been publicly done in that art up to that time (though, as a matter of fact, no person with such universal knowledge ever does exist), but it does not follow, therefore, that the law presumes that even persons with the supposed knowledge of all that had been done, necessarily could know what is really true, or what is really erroneous, or could so infallibly distinguish between the true and the false, as to be able to combine only what is true, and the best of what is true, so as to produce the highest and best results. Mr. Pope, the defendant's expert, admits that he knows of no patent or publication, prior to August, 1880, which points out the necessity or desirability of locating any drop of tension in excess of a negligible amount, in that past of a system of conductors nearest the generator, and having no lamps connected therewith.

The different prior publications, patents and uses set up as specific defences are next to be considered. The diagram of Werdermann's British patent, No. 2,477 of 1878, was perhaps an attempt to deal with the problem of simultaneously supplying a number of lamps under such conditions that they would burn at equal candle-power. The arrangement is what is known as "reversed parallel," because the position of the return conductor with reference to the first and

last bridges is reversed from its position in simple parallel. Werdermann's diagram, which is intended to represent an extended system of distribution, clearly contains no division of the system into feeders and consumption mains, and it is also to be noted that his lamp is not an incandescent lamp. His proposed remedy was, not to limit the consumption circuit to dimensions on which the drop in tension was negligible, nor to divide a large system by points of feeding so that the drop in tension in each part should be negligible, but it was rather the fallacy of creating "equal electrical distances" to each lamp and to enable any sized consumption conductors to be used. Nor was it his idea to use feeders freed from any and all connection of lamps and translating devices. Khotinsky's French patent, No. 107,307 of 1875, was before the Patent Office on the grant of the patent in suit, and was then overruled as a reference. The drawings illustrate an ordinary multiple arc circuit, supplied at different points by a machine. There is no intimation in the patent that the inventor contemplated any plan of dealing with the difficulties of drop of tension in an extended system; nor that the connections from the machine to the lamp circuit were anything more than the ordinary connections from a machine to a circuit in close proximity therewith; nor that any economy in construction was made possible; nor that any regulation of current with varying numbers of lamps could be facilitated. It gives no consideration or direction which teaches anyone how to maintain uniform candle-power, or uniform pressure, in an extended circuit. The courts have repeatedly held, that a prior description, in order to invalidate a patent, must be such as to show that the article described in the patent can certainly be arrived at by following the prior description. The general statement of the defendant's experts as to the similarity of the Khotinsky arrangement of circuits to that of the patent in suit, and to the effect that the details of construction specified by the patent in suit would be understood from Khotinsky's patent by those skilled in the art, are abundantly controverted by the evidence of the complainant's experts. Sir William Thomson says that Khotinsky "does not suggest anything towards the illumination of towns, or the carrying of the electrical energy to considerable distances. He does not contemplate any difference of pressure in different parts of the circuit; there is certainly nothing in any part of his patent which gives any indication towards the solution of the problem discovered by Edison." The testimony of Prof. Chandler and Mr. Jenks is to the same effect. In the British patents of Lane-Fox, Nos. 3,988 and 4,626, of 1878, and his letter to the London *Times* of December 26th, 1878, as expressly admitted by Mr. Pope, defendant's expert, he does not point out any specific arrangement for accomplishing equalisation but merely says that it is to be done by properly arranging and proportioning the conductors. There is in the Lane-Fox patent no scheme for a division of the system of conductors into two parts, one for supplying and regulating the current, and the other for consumption, and the connection of the supply circuit, and the proportioning of the consumption circuit in such a way that there shall be only a negligible drop in tension on the consumption portion. On the contrary, his idea was to use the whole system for consumption, and while probably aware that this would involve a ruinous expense for copper, yet he saw no remedy for that difficulty except that of placing local regulators at each branch, or introducing storage batteries at distant points, and by using an earth return, all of which devices have proven to be wholly impracticable.

The publication in the *Scientific American*, in 1877, illustrates an electro-plating apparatus described by Weston as an ordinary electro-plating bath. None of the distinguished scientists examined before the British Parliamentary Commission of 1879 appear to have supposed that the secret of proper electrical distribution lay hidden in the everyday practice of an electro-plating bath. The analogies to the operation of an electric lamp are so distant, and the structures, consisting of soluble anode, liquid electrolyte, and temporarily inserted cathode, are so totally unlike anything existing in the incandescent lighting art, as to destroy any possibility of treating this compound apparatus as the equivalent of an electric lighting plant. Sir William Thomson says that "there is absolutely nothing in common in the two cases between the respective difficulties and the respective arrangements for overcoming them."

The proof in regard to the use, in distributing systems of gas and water, of what are known as "independent mains," is comprised in a number of early publications and oral evidence in regard to a number of early plants. It may all be summed up briefly by saying that it appears that for half a century it has been the custom to lead "independent mains" from reservoirs of gas and water to distant consumers, and in some instances to assist overloaded systems by carrying pipes from the reservoirs directly to overloaded points with a view of supplementing the supply at such points. The proposition of the defendant is understood to be, that the known analogies between the laws which govern the flow of fluids and those which govern the so-called flow of electricity, are such that an electrical engineer, in 1880, by the exercise of ordinary skill and knowledge, would necessarily have distributed electricity by a division of the system into consumption and feeder circuits, by proportioning the consumption circuit so that the drop in tension between the several lamps would be negligible, and by bringing the total amount of copper in the system within practical limits, by localising on the feeders whatever drop in tension was necessary to be incurred to accomplish such economy. The complainant's experts, on the other hand, contend that the problem was essentially different in the two cases; that the difference between the ponderable bodies known as gas and water and the imponderable something, which we call electricity, are radical; that the laws governing the so-called flow of electricity are different from those governing the flow of gas and water; that the surrounding and interfering conditions are widely dissimilar; that the characters of the conducting systems are unlike, in that one requires only an outflow system, while the other requires an outgoing and return system; that the conditions of economy are very unlike as between hollow pipes and solid conducting wires; and that the incandescent lamp bears no analogy to any device for allowing the consumption of gas or water; hence that the rough analogies which exist between the two systems were not sufficient to teach the electrical engineer that the idea of the so-called "independent main" could be transferred to and adapted to a system of electrical distribution, or that the desired problem of distributing electricity so as to maintain equality of candle-power throughout an extended system, with reasonable economy in the cost of conductor, could thereby, or otherwise, be solved. The opinions of the defendant's experts as to the teaching analogies of gas and water distribution, and their effect in vitiating the novelty of Mr. Edison's invention are stated by President Morton and Mr. Pope; but, on the other hand, the testimony of the witnesses for the complainant, Sir William Thomson, Prof. Chandler, and Messrs. Brevoort and Jenks, is specifically to the contrary, and the reasons given seem to be satisfactory and conclusive.

The complainant contends that Mr. Edison was the first to deal with an extensive system of distribution, so as to secure uniformity of operation throughout, by the mere arrangement and proportioning of the conductors; the first to establish as the standard of uniformity of pressure on such circuits, the maintenance of equal candle-power; the first to supply circuits located at a distance by means of conductors set apart for supplying regulation only; the first to teach how loss of force in reaching distant points with economy could be endured without impairing equality of force where it was to be utilised, and the first to provide a system by which not only uniformity of candle-power or pressure could be produced over an extended area, but such uniformity could be maintained under all variations of consumption, because the loss, whether constant or variable, did not affect the consumption.

It is contended by defendant that the patent is void because it covers a necessary and inevitable mode of construction which would naturally be adopted in supplying a small building with electricity from a distant source. This argument sounds plausible, but it is not sound; no one did, in fact, prior to 1880, construct any such system. Why should the idea of using the lamps in multiple arc arrangement, and the further idea of supplying such an arrangement from a distant generator, necessarily occur in connection with each other? It requires the connection of those two ideas to make the imaginary case of the defendant. But even if this combination of ideas had actually been made, or such small installation had been actually set up, it is clear that it would have been done without any thought of any problem having thereby been solved of the distribution of electricity over large areas

It is contended that this invention is a mere matter of engineering and would naturally occur to any engineer. Are not all inventions the result of the working of the law of supply and demand, which, when an invention is needed, stimulates trained minds to work it out? Is not an inventor one who merely hastens the inevitable evolution of thought? The courts have often said that an invention may be made in a flash, but they have never said that it must be so made, or that it may not be made as the result of a thorough and intelligent working out of a problem. The final perfection of all improvements is often removed by only a short space from previous impracticable contrivances. In this, as in all other things, as the proverb says, "Perfection lies in little things, but perfection itself is not a little thing." It is the finishing stroke that counts. The Supreme Court has said, "In the law of patents it is the last step that wins."

The defendant contends that the application for a patent, as originally filed, does not contain the invention as now defined; but this is an error. The drawings are the same as those found in the patent as granted, except that some figures have been erased, and the claims originally filed, though more general in phraseology than those now sued on, evidently include the same subject-matter. The effect of the amendment to the specification in its progress through the Patent Office, was merely to eliminate objections based on the generality of the language first used, but not in any way to alter the character of the invention.

It is submitted, therefore, that the feeder and main invention of Edison, was one involving invention of high class; that it was not anticipated by any constructor, nor found described in any prior patent or publication; that it is clearly infringed as to the first three claims; and that complainant is entitled to a decree.

CORRESPONDENCE.

The Bremen Electric Tram Line.

We notice in your issue of May 20th, page 632, some remarks about the Bremen tramway, entitled "Difficulties of an Electric Tram Line." We beg to state that the information there given requires some correction.

No difficulties have been encountered in the Bremen work in the adaptation of all the details of the well known overhead trolley system to meet the requirements of the Imperial German postal authorities and the Bremen municipal authorities.

The German postal authorities wished to avoid as much as possible any disturbances to telegraph or telephone lines, and asked nothing at all unreasonable, or which could possibly be interpreted as evincing hostility on their part to the use of "heavy currents." It was anticipated that there would be noises in the telephones, before the line was

built; however, when finished, it was found that throughout the general telephone net no appreciable disturbing sounds were to be heard. On three outlying private telephones at the end of a track 6 kilometres long, telephone disturbances were expected, and were noticed; these disturbances were done away with by the use of a common *metallic return* to the town *for the telephones*.

The Post Office also required guard wires, so that no other wires could come into contact with our trolley wire. These guard wires were not required over the whole line, but only in the heart of the city, or where there were wires crossing the line outside the city.

The city authorities themselves prescribed nothing more than neat construction, and the avoiding of anything that could hinder the firemen in manipulating their ladders.

Instead of poles to support the span wires in the heart of the city, iron rosettes to hold the insulators are placed on the walls. In one of the very narrow streets switches have been provided, so that that section of the line can be entirely cut out, in case the firemen have to work there.

The slight accident referred to happened before the line was ready, and would never have happened if the telephone workmen, who were putting up new wires, had given notice that they intended to do such work. The generators and two or three cars were running merely for trial purposes, and the wiremen did not know that the current was on. This is an accident that could not happen with the proper care that was always observed by telephone wiremen when the line was running regularly two years ago during the exhibition time.

The trolley wire did not break and fall on any other wire, but the telephone wires during some new construction work fell on to the trolley wire at a part of the line where there were no guard wires, and where none would ordinarily have been required, as there was no crossing of wires at that point.

The Bremen municipal authorities, who, by the way, include an able electrician, thoroughly understood that the accident to the telephone and the lineman referred to would not have occurred under ordinary circumstances, and that it was simply due to a misunderstanding, owing to the telephone linemen having failed to give notice to the power station.

It would be impossible to ask more reasonable and agreeable people to deal with than the German authorities have shown themselves throughout, in connection with the construction of the first modern overhead electric tramway introduced into Germany.

Thomson-Houston International Electric Co.
E. THURNAUER, *General European Manager.*
May 27th, 1892.

The Fatal Fire at Scott's.

I have read your remarks on the nature of my evidence at the adjourned inquest on the fatal fire at Scott's supper rooms. You are right in supposing that my evidence has been incorrectly reported (a not uncommon circumstance in a non-technical report of a technical matter), but you are wrong in one or two minor details, and moreover you do not, I think, appreciate the capacity in which I was called upon to give evidence.

As the question of the safety of the electric light in houses is one of grave moment, I will be glad if you will allow me space to correct some misunderstandings in the matter.

I have pointed out where you are right. I will now show you where you are wrong.

You are wrong (1) in suggesting that my statement as to where the insurance was effected was made upon "mere hearsay." The proprietors (who certainly should be the best authority as to where their property is insured) informed me that a portion of the risk was placed in the Phœnix Fire Office.

(2). You are wrong in stating that at the end of my evidence I came to the conclusion that the fire at Scott's was *probably* caused by a leak. My answer to a juror who asked my opinion as to whether the fire *was* caused by the electric light was as follows:—"I think it is distinctly *possible*, but I can find no tangible or definite evidence to that effect." (See *Standard*, May 21st, 1892.)

Let me now explain the direction in which I was asked to give evidence.

The fire you will recollect occurred on the 9th inst. and the inquest on Friday the 13th inst. At the inquest no clue could be obtained as to the cause of the fire, and in accordance with the request of some of the jury, who were of the opinion that as the fire occurred in that part of Scott's rooms which was lighted electrically, the cause might be due to some defect in the wiring, the Coroner adjourned the inquest in order to obtain expert evidence—not as to the cause of the fire—but, as the Coroner very distinctly put it to me, whether or not it is possible for defects in the system of putting up electric light wires to cause a fire, and if so whether or not there were evidences of any such defects having existed in the system of wires as erected at Scott's supper rooms. (See the *British Architect*, of May 27th, 1892, which seems to be the only technical paper which has correctly understood the direction in which my opinion was invited).

I wish you to note that my opinion was invited, not on the cause of the fire in the first instance, but as to whether there was a possibility of a fire having been caused by defects in the system on which the wires may have been run.

As I stated at first in my evidence there was not much to be seen or gathered from the ruins, but at a point whence the fire could have originated (this view being moreover not inconsistent with the way in which the fire had spread), I found that the main casing had been run alongside of a gas main for about 11 feet. I hold that this was reprehensible, and I repeat what I said in evidence, that I am sure Mr. Musgrave Heaphy had not an opportunity of inspecting this work, or he would not have passed it.

I brought this forward in evidence to show how essential it is in the interest of consumers of electrical energy that fire insurance companies and supply companies should press for power to inspect and test at odd intervals during the progress of the work and not only after completion; and also to show the danger of systematically concealing wires and putting them anywhere out of sight, simply for the sake of appearance. Mr. Heaphy, would, I am sure, be the first to endorse my views, and how my evidence in this direction could have been twisted and turned to imply a slur on Mr. Heaphy, I am at a loss to understand. As, however, this latter view seems to be shared by many of your contemporaries, let me take this opportunity of stating that in my articles on the wiring of houses for the electric light, published in your and other journals, I have more than once paid a tribute of praise to this gentleman for having always shown that he had the courage of his opinion during a very trying period in the history of electric lighting, and for having produced a code of rules for the protection of buildings lighted by electricity which has been adopted by the leading insurance offices throughout the world.

Far from any wish to disparage Mr. Musgrave Heaphy, I may take this opportunity of stating that the steady and rapid advancement of incandescent electric lighting is in no small measure due to the severity of Mr. Heaphy's judgments on anything approaching carelessness in the system of wiring of buildings.

In fairness to Mr. Heaphy I may say that what I said in evidence is perfectly correct, for I am able to state on the best authority that a portion of the risk in Scott's supper rooms was only recently transferred to the Phœnix Fire Office, that the office did not know the building was lighted by electricity, and that consequently Mr. Heaphy was never invited to inspect the installation. It is further worth mention that the Phœnix Fire Office do not propose to raise any question as to whether or not they should have had notice to inspect.

As regards the suggestion that I influenced the minds of the coroner and of the jury, adversely to electric lighting, I will just quote the following, which occurs in my report to the coroner: " . . . It may therefore be not out of place to mention that if the wiring is carried out *well* and in accordance with sound principles, good design and intelligent workmanship, and under competent supervision the electric light is safer than any other form of illuminant." I will further ask you to remember that the jury who were previously prejudiced against the electric light to the extent that they asked for an adjournment of the inquest, returned a verdict that the cause of fire was unknown, after hearing my evidence. These facts speak for themselves, and I can only in conclusion state that the extraordinarily distorted views expressed in some of your contemporaries on the nature of my evidence, do not reflect creditably on the common sense of those responsible for them.

Ed. C. de Segundo.
May 30th, 1892.

Inductor Alternators.

But little can be added to Messrs. Rankin Kennedy and Mann's able defence of the inductor type of alternator; but answering your statement a little more critically, we must point out that in our machine the minimum number of magnetic lines passing through the induced current coils will be a much smaller proportion of the maximum than 50 per cent., and, as far as we can judge does not exceed 5 per cent. Also we fail to follow your inference that in the inductor type of dynamo the number of lines of force cutting the induced current conductor is necessarily smaller than in a machine of the ordinary type. We know of no alternator of any kind that is so simple, compact, and strong and with so few working parts, which in themselves are so simple and require so little machining. We shall be able to demonstrate this more forcibly when the commercial question comes to be considered, as these points will undoubtedly give us a fair share of the alternator trade.

We would ask your readers to peruse your leaderette, and while marking your statement "Messrs. Pyke and Harris have recently devised a modified form which appears to be inferior, owing to complication of details, multiplicity of parts, and lack of mechanical strength," at the same time examine the patent drawing reproduced by you, or better still, the machine itself, which, it is hardly necessary to point out, does not exactly tally with the drawing.

The heating of the field magnets and inductors is quite unappreciable; the reason of this should be obvious to any person examining the design of the machine.

The reason why Mr. Mordey and Prof. Elihu Thomson abandoned their inductor type of dynamo would probably be quite apparent to us if we could see the designs; but we were not aware of such machines ever having been in existence, or are we acquainted with any one who has seen them in use.

If any of your readers are desirous of comparing your criticism with the machine, we shall be happy to show it to them at any time. We shall have a couple of similar machines ready, for parallel running, in a few weeks, and we should esteem it a favour if you would pay us a visit and see what can be done.

Pyke & Harris.

May 30th, 1892.

Railway Train Lighting Plant.

Our clients, Poole and White, Limited, have called our attention to the article in the last issue of the ELECTRICAL REVIEW on "Railway Train Lighting Plant." With the exception of the dynamo, almost the entire plant described is the joint invention of Mr. Houghton, and Mr. White the managing director of Poole and White, Limited, and that company made the plant for the Brush Company. Hence it was in no sense *designed* by the Brush Company as stated in your article. Moreover, Poole and White, Limited, are sole licensees for the manufacture of the plant in question.

Owing to our remonstrance with the Brush Company, they have undertaken to send you for insertion a corrective statement, and Mr. Houghton, we believe, will also ask you to insert a letter of his on the same subject. Fully believing that you could not have been aware of the facts, or you would never have inserted an article so injurious to our clients, we only ask you by way of reparation to give the fullest prominence to the corrections. You will at once see how damaging such a misstatement must be to our clients' interests, as the various persons interested in train lighting have been misled as to who is able to supply what is, we believe, the best known apparatus.

Saltwell Tryon & Saltwell.

May 30th, 1892.

Referring to the description in your last week's issue of a railway train lighting plant inspected by you at our Lambeth works, we think it right to mention that the automatic devices are constructed upon the designs of Mr. Houghton, of the London, Brighton, and South Coast Railway, and of Mr. White, of Poole & White, Limited, of 58, Bread Street, Cheapside. The last mentioned firm are, we understand, sole licensees under the patents for the above devices, and supplied the gear to us.

Brush Electrical Engineering Co., Limited.

I hope the readers of the article in your issue of 27th inst. will not conclude that we have not advanced any further in this speciality than was indicated by the trial at the Brush Company's works. Anyone acquainted with the requirements of lighting trains by electricity knows that to commence charging accumulators at from 15 to 20 miles per hour or thereabouts is practically useless for local, suburban or stopping trains. It generally answers fairly well for main line or fast trains, but even for such traffic in foggy weather and on exceptionally busy occasions, when ordinary speeds cannot be run for perhaps two or three days in succession, the storage is so much trenched upon through the trains not reaching sufficient speed to charge the accumulators, that the lighting is liable to become defective.

With the regulating apparatus now in use, we commence charging at about six miles per hour, frequently before the train is clear of the platform, and continue to do so up to any speed, thus securing the very important desideratum of enabling local trains to run on the main line, and *vice versâ*. By means of the governing apparatus in question, it is immaterial how high (within reasonable limits) the E.M.F. of the dynamo may be. For example I am running a 130-volt machine with 60-volt lamps up to a speed of over 60 miles per hour. The majority of the dynamos in work on this railway for train lighting go up to 90 volts, and have 42-volt lamps on them. Will you, in justice to my friend and fellow worker, permit me to say that the automatic regulating apparatus used at the trial you quote is, with the exception of some alterations made by the Brush Company, the invention and patent of Mr. Wm. White, of Poole and White, Limited, 58, Bread Street, E.C. (who are the sole licensees), and myself. It has been in practical work for a considerable time, and is employed on a number of trains.

E. J. Houghton.

May 30th, 1892.

Transformers.

I did not know till you sent me a proof of my paper that you would care to publish it *in extenso*. As you are doing so, may I ask you to publish also this letter. I have observed that some writers complicate very unnecessarily the mathematical expressions in which alternating current problems are dealt with, putting as a difficult *page* what ought to be a very simple and easily understood *line*. This paper may be easily understood by anyone who knows a little algebra and trigonometry, and the meaning of differentiation, and such a one has only to make an effort, and he will at once understand it. He must, however, take for granted that, in all calculations throughout the paper, except when we have to cranslate into ordinary language the meaning of a result, θ tan be treated as if it were an ordinary algebraical quantity. The reason for this cannot be given in a few words. If it were better understood, it would be seen that all sorts of problems on alternating currents, involving the use of condensers, &c., such as the rise of potential in mains which have capacity, can be worked out in a few simple mathematical expressions. A numerical example, or two of the use of (3), worked out after reading Section III., will make a student quite familiar with this kind of easy mathematics. If he is a practical man he is already familiar with it, because this is the way in which he *thinks* about transformers. In the same way, every practical man thinks about periodic functions according to the ideas of Fourier, and it only needs an hour's explanation, and a little working of numerical examples, to enable him to use the mathematical method of expressing his thoughts, of which, as a rule, he is so much afraid. One result of this is that the men who think according to Fourier, cannot write and leave the writing of Fourier ideas to men who have never really used them in thought.

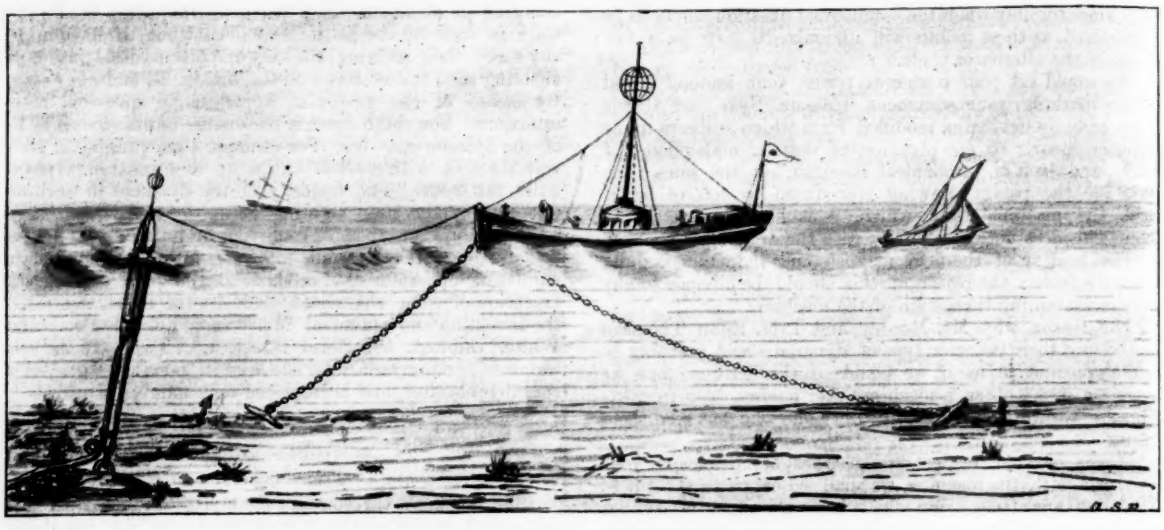
John Perry.

May 25th, 1892.

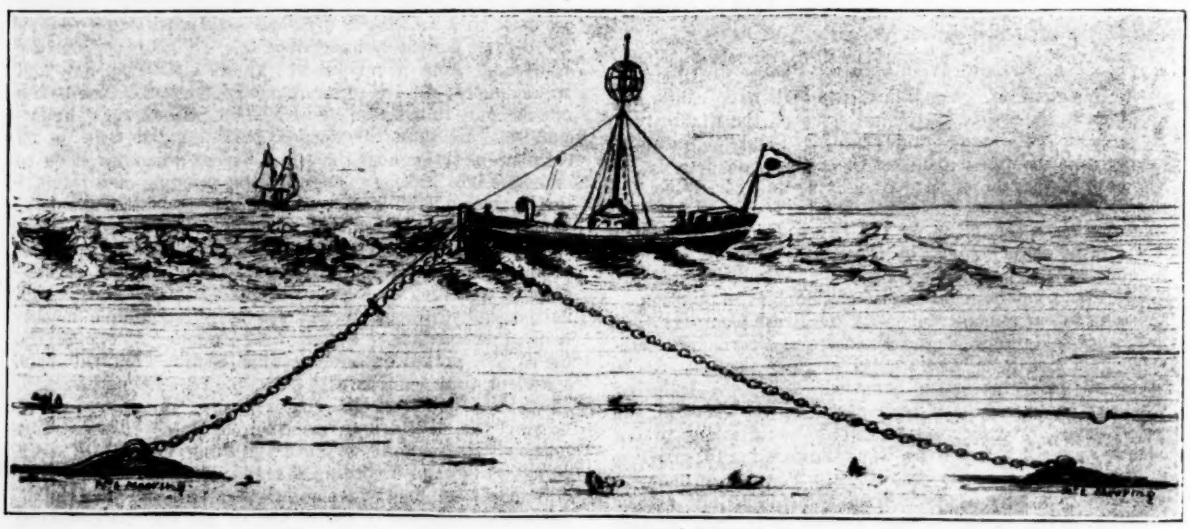
Electrical Communication with Lightships.

Permit me to send you a short communication which will not be much trouble for you to read, and which requires no answer, and is yours to use as you think fit. The article in the ELECTRICAL REVIEW, date April 29th, subject: best means of getting a telegraph cable on board a light vessel, moored, as shown in your "cut," with two anchors. The question is an interesting one, and being in the cable

business personally, and often having to puzzle over the best means of landing and handling submarine cables, a notion has occurred to me, which I send you for what it is worth. I have cut out and re-enclose your sketch, to emphasise my own. The spar buoy is good, and determines a stationary point at the bottom of the sea, where one part (and that a vital one) of the telegraph cable will be at rest. But why have the buoy at all? Why not the spot where the bottom of your buoy is moored be the light vessel's moorings, using whatever kind of anchor is best for the purpose? Then, instead of the telegraph cable hanging in a long bight from the top of a buoy to the bow of the vessel, bring it (the telegraph cable) up along the chain cable of the lightship, and secured to it for some distance up, to a point where any at a constant angle to ship, and another fixed point above water, viz., the ship's bow, where the lead of both chain and telegraph cable would not materially alter at change of tide; then it would appear, on the face of it, that under the given conditions above no damage of a serious nature would happen to a telegraph cable guided along and secured to, as suggested, the chain cable of the light vessel. Both chain and telegraph cable would, above and below water, with the permanent mooring (as No. I. or II.) form an integral part of the vessel and her system. Means could be taken to give extra protection to the telegraph cable, where it would lay on the bottom from the mooring before raising towards the ship. A few fathoms of the pliable chain, as described in your issue of February 12th this year, would do well for that, or



SKETCH WHICH APPEARED IN "ELECTRICAL REVIEW," APRIL 29TH.



SKETCH SHOWING SUGGESTED MODIFICATION.

veering or heaving in of chain takes place, then from that point to the hawse let the telegraph cable hang free, following the lead of the chain cable, but passing in at the bow clear of it through an independent connection. The general idea of this I have endeavoured to show in the rough copy of your sketch, and enclosed with it. I do not know whether the plan would suit a light vessel laying at single anchor, where swinging and probable sweep of chain would take place; but for a vessel moored as shown in your sketch, it would appear to be suitable, for in the latter case, though the body of the vessel would swing with the tide, I take it the bow might be looked upon as a pivoting point, and more or less stationary. Now, having one fixed point below water (either mooring anchor), where both telegraph ships' cable lead out together otherwise. To hang a long loop of telegraph cable from the top of a spar buoy to the bow of a vessel in a rough sea, with the ship pitching heavily, seems a somewhat hazardous proceeding for the cable. Does it not also appear doubtful whether the lightship authorities would ever consent to moor their vessels to the top of a spar buoy, in place of the present system? Now, I hope you will pardon the trespass committed on your valuable time; being interested, the thought struck me to place before you the light in which I viewed the sketch in your excellent April number of date April 29th.

Ernest G. Schenk, *Commander.*

Cable steamer *Mackay Bennett*, Halifax, N.S.,
May 12th, 1892.

CRYSTAL PALACE ELECTRICAL EXHIBITION, 1892.

Telephone Exchange Switches.—(*Continued from p.* 686.)

The standard switchboard of the Western Electric Company (fig. 22) is suitable for exchanges accommodating up to about 300 subscribers. Connection between the

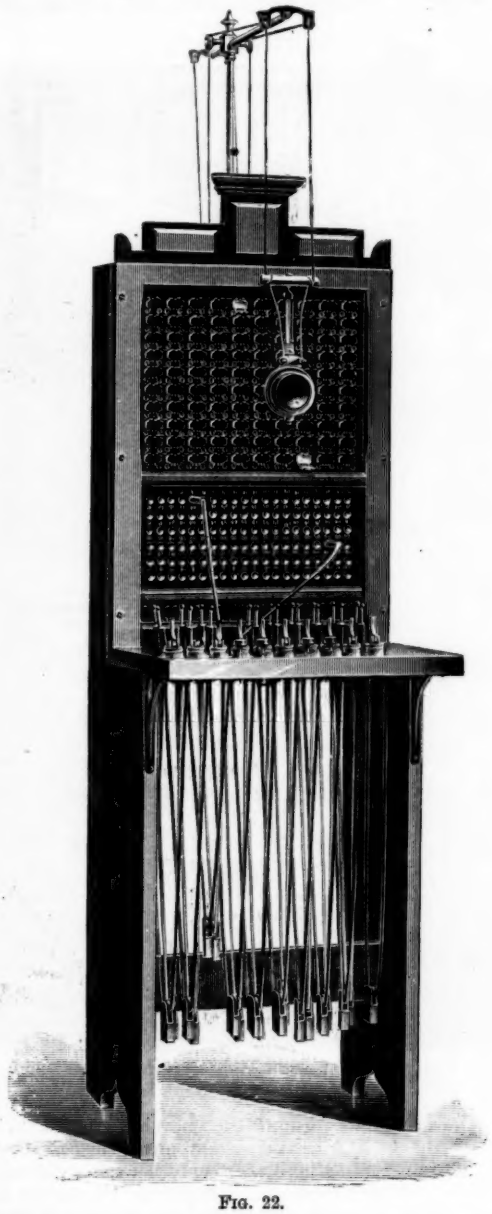
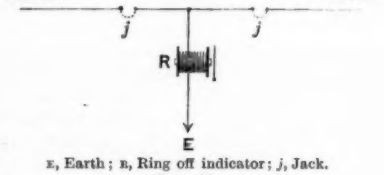


FIG. 22.

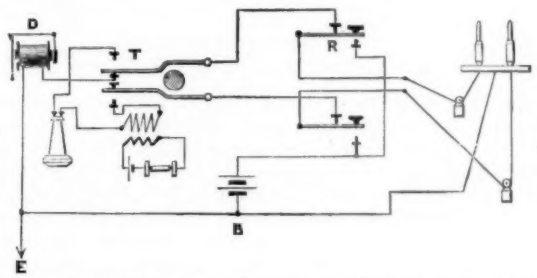
different boards in such a case is obtained by means of auxiliary wires connecting spring jacks placed below those of the subscribers' lines. The subscribers' indicators are employed



E, Earth; R, Ring off indicator; *j*, Jack.

FIG. 23.

solely for registering calls. When two lines are connected together these indicators are temporarily thrown out of use, and a separate ring off indicator employed. This latter indicator is placed in a shunt, or derived circuit (fig. 23), in order to get rid of the injurious effects of the self-induction of the electro-magnet upon the speaking. The ring off indicators have a single coil wound to a resistance of 1,000° ohms. The coil is enclosed by an iron cylinder similar to the altandi electro-magnet patented by John Faulkner in 1877. The construction of the ring off indicator, electrically and magnetically, is therefore such that the maximum impedance is offered in the shunt circuit to the rapidly alternating speaking currents, but the relatively slower ringing currents are virtually unaffected. Fig. 24 shows the



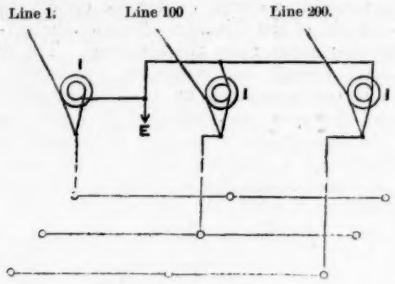
D, Ring off drop; T, Table key; B, Ringing keys; E, Earth; B, Ringing batte

FIG. 24.

connections for switching into circuit the operator's instrument or ring off indicator. The levers of the table key are movable between the contact studs and make connection in one position with the outer, and in the other position with the inner stops. Eight operations are required on the part of the attendant to effect a connection between two circuits on the same switchboard and restore to the normal condition. When the line of the called subscriber is upon a distant switchboard the connection must be made through an auxiliary local connecting wire, and this can only be done with the assistance of a second operator, but connections may be made direct to the boards within reach of the operator on each side. In exchanges where the number of circuits concentrated exceeds 300, the additional work thrown upon the operators in making these extra connections and the consequent delay in establishing communication, necessitates the introduction of multiple switches. The Western Electric Company are the proprietors of the patents for these switches in this country, and they exhibit one section of a single cord Scribner's metallic circuit multiple switch capable of accommodating 6,000 lines and 200 indicators. Such a section would be managed by three operators, and the compactness of the jack springs will be appreciated when it is understood that the space occupied by the 6,000 jacks is 71 inches long by 26 inches deep, All the lines are therefore directly accessible to each operator. Each subscriber's line terminates in a jack, to which is also connected a cord and plug. The object of this is to enable communication betweeen two lines to be established by the operators with a minimum number of movements on their part, and thus effect an economy in the time required to do the work, for which six operations are necessary; the internal connections are somewhat complicated The company also manufactures a double cord multiple switch, in which the ring off indicators are placed in a derived, or shunt circuit, as in their standard form, and which requires the same number of operations to effect a connection, that is, two in excess of the single cord board. Greater simplicity of internal connections (by no means a negligible item) is, however, secured in the double-cord board.

At the Consolidated Company's stall is exhibited, for the first time, a multiple switch for single lines, in which the indicator coils are wound differentially, and have their inner ends connected to the contact sockets, one outer end being joined permanently to earth and the other to subscriber's line. The contact sockets of each subscriber's line are permanently connected together upon each section of the board, as illustrated in fig. 25. It will be noticed that a

calling current from any section of the board would traverse the indicator coils upon the called line in opposite directions, and no effect would be produced, but an incoming current from the renter would pass through the two windings in



I, Indicator; E, Earth.

FIG 25.

series, and drop the shutter. When a connection is made between any two lines by a single cord and pair of plugs, one winding of each renter's indicator is included directly in the line circuit, and must be spoken through, the other windings forming branch circuits or leaks to earth. A special plug is provided for the use of the operator, and in its handle is contained a finger switch which normally connects the switch telephone to line, but which when depressed—as may be done with great rapidity—connects the ringing battery or generator to line. Some special device is usually provided with multiple switches, to enable the operator to ascertain whether a called line is free. In this case, it devolves upon the operator to plug in and listen to determine this. As there are frequent pauses in telephonic conversations, the method is liable to be very misleading. Apart from this, however, it has several defects, the chief of which, we think, is that the position of the electro-magnets in the speaking circuit renders its use inadmissible for present day requirements. The workmanship and design are excellent; indeed, the Consolidated Company's stand contains a selection of apparatus which for variety and general superiority of workmanship is not excelled.

Visitors to the Exhibition who desire to acquaint themselves with the intricacies of telephone exchange working, have ample opportunity afforded them by the National Telephone Company, who have fitted up and connected with their general system, a complete working exchange. It includes a testboard fitted with test jacks and lightning arresters of the Coleman and Jackson type. The switchboard, which has a very effective and imposing appearance, is arranged for metallic circuits, and accommodates 100 lines, 10 of which are set aside for junction lines to other exchanges. Vulcanised fibre is the material employed upon which to mount the spring jacks. The single cord principle of connection is adopted, and the indicators, wound to a resistance of 1,000 ohms, have two coils enclosed in iron shields. The spring jacks are arranged so that when a plug is inserted, the indicator is disconnected. When two lines are connected the indicator of the called subscriber is cut out of circuit, that of the calling renter being retained in shunt circuit as the ring off indicator.

Automatic Call Box.

The establishment of call offices, whence the general public may obtain communication with the telephone exchange, has led to the invention of many descriptions of automatic call boxes, by means of which the caller may be enabled, upon the payment of a fee each time he uses the apparatus, to obtain automatically a connection with the district exchange. The International Electric Company exhibits a very ingenious and well made instrument of this description, illustrated by fig. 26, by Mix & Genest, Berlin. The telephone is normally disconnected from the exchange line, the connection being effected by the coin inserted into the apparatus in payment for the conversation.

Upon the coin being inserted into the slot, S, it first passes through an arrangement, P, for testing its diameter, thickness and weight. Should it fail to pass these tests, it is rejected and falls into the refunding box, C. Ordinarily, however, it is satisfactory, and passes to a pair of grooves, R, which are movable upon a hinge, X, where its progress is arrested by the upper of three-wheel segments, r, r^1, r^2, which protrude into the sides of the grooves, R, R^1, and are actuated by the armature, A, of an electro-magnet, N, thus forming a check arrangement. Just before reaching r, the coin presses a small projecting lever, the movement of which lever effects connection between the line and apparatus. The Exchange is then called and answers in the usual way. If for any reason the communication required cannot be given, the caller is instructed by the switch clerk to press a white

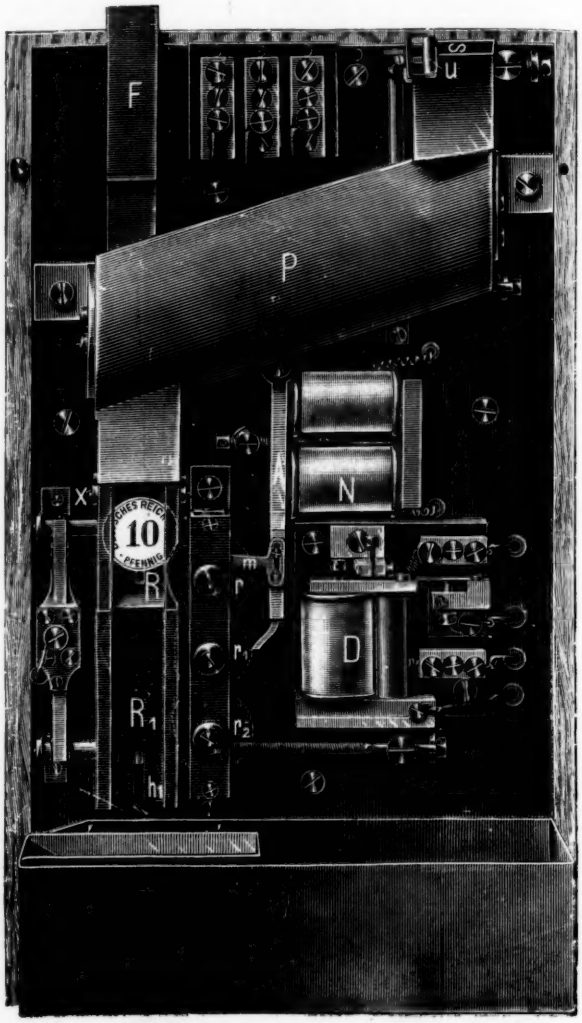


FIG. 26.

stud, which throws forward the movable grooves, R, and releases the coin from the check arrangement, allowing it to fall into a refunding box, whence the caller recovers it. If the connection required is established, the switch clerk sends a current through the electro-magnet, N, and attracts its armature, A, with a force sufficient to overcome the pull exerted by the spring, f. The coin then falls into one of the fixed grooves, R^1, but is arrested by the segment, r^2. At the close of the conversation it is finally released by the armature of the electro-magnet actuated by the ring off signal, and falls into the cash box, pressing *en route* a second lever, i^1, which being connected diagonally by a bar with i, replaces the latter and disconnects the apparatus. If the closing signal is omitted, the coin will remain in the groove, R^1, and resting upon the wheel segment, r^2, but in order to clear the grooves for the coin of the next comer, a lever is attached to one end of the armature, A, and terminated at the other by a small roller, u, which projects into the slot, S. By means of this lever the armature is actuated mechanically upon the insertion of the next caller's coin, and the one left in the groove falls into the cash box, before that being inserted has passed through the testing device.